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LIGHTING AND POWER IN HOTEL SECOR, TOLEDO, O.

IN a modern hostelry, the comfort of guests makes large demands upon the mechanical equipment of the building. "Ye Olde Tyme Inne," which needed only to offer a rousing fire in the tap room and a mug of ale will no longer serve, but in order to be up-to-date, the dapper clerk must supply lodgings which are steam heated and with hot and cold water, tiled bath room with porcelain fittings, telephone service; and within the hail of the telephone must be a staff which can supply all personal needs of guests. While to cater to our pampered appetites, the chef must serve us with viands from every country, which necessitates not only the best appliances for cooking and greatest care in handling, but means for storing at the exact temperature best suited to the raw provisions. And the chief engineer of the hotel is expected to furnish currents of hot or cold air, boiling or ice water, red hot electric current or a brine current that is at zero, and the latest burden added to his many tasks —he must now do the sweeping for the chambermaid. In the modern hotel even more than in any other building, our comfort depends upon the engineer and the power plant in his charge. So it comes that one of the first considerations in the laying out of any building for hotel purposes is the mechanical equipment. In the Hotel Secor, this equipment has been carefully planned. All the many needs above enumerated have been taken care of and furthermore, the hot or cold air, as may be required is washed before being used.

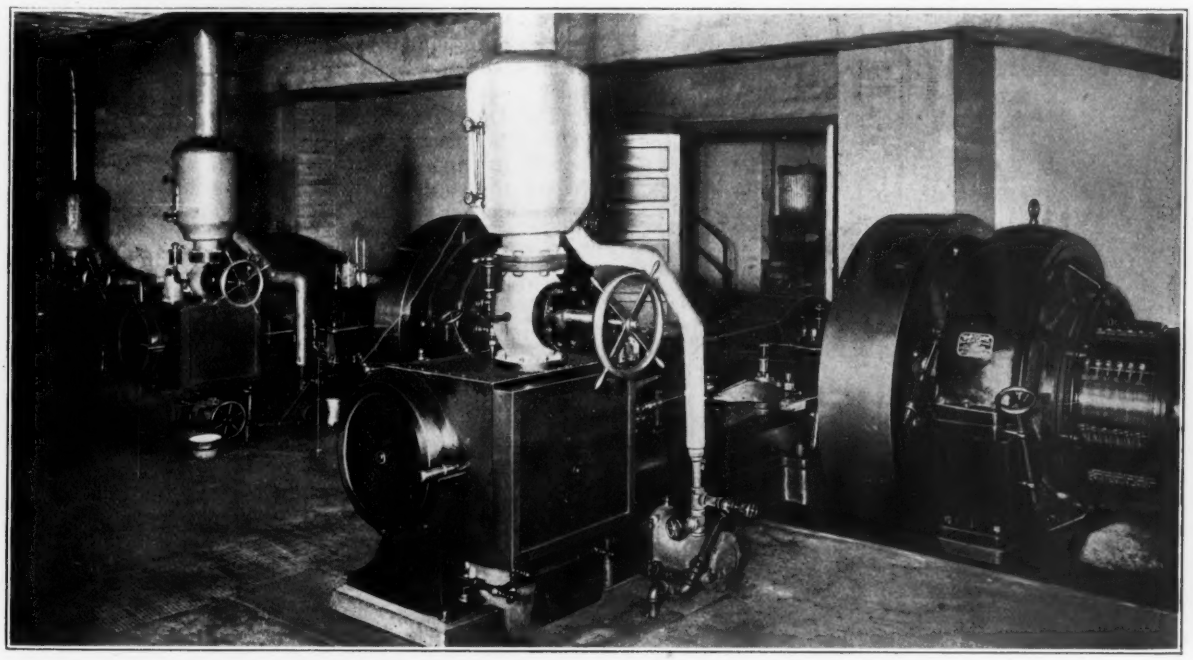


FIG. 9. GENERATING UNITS IN THE ENGINE ROOM

We demand and the modern innkeeper furnishes not only comfort but luxury and artistic surroundings. Even those of us who in our daily home life are accustomed to a modest cottage and bringing up our own coal, when we travel from our own firesides would indulge ourselves in beamed ceilings, frescoes and marble columns; and the bell-boy must serve us with ice water when we will; and those of us who are forced by grim fate to compress ourselves into the conventional city flat must needs have spacious hallways, high ceilings and wide stairways.

Figure 1 shows the building which has been provided to house the comforts for the wayfarer who fares to Toledo. It shows the character of the building and the equipment throughout does not belie the promise made by the exterior.

Lighting

In a large public building, one of the most difficult features to arrange satisfactorily is the lighting of

FIG. 1. EXTERIOR OF HOTEL SECOR

the main rooms. The group Fig. 2 shows how this has been accomplished in 3 of the main rooms in this building and the same principles have been employed throughout the other rooms. For instance, in the main foyer, the central space is lighted in daytime by skylights and at night by electric lights placed above the skylights, while the spaces at the side are taken care of by single lights set along the beams and clusters pendant from the ceiling.

The same style of lighting is used in the main ballroom and in one of the dining rooms, while another dining room has torch fixtures on the side walls, and overhead prism baskets containing a cluster with single lights set around the outside. The views speak for themselves as to the artistic merit of the fixtures used and the harmonious effect secured by the lighting scheme employed.

In the writing and lounging rooms are shown a stalactite fixture which in single form, is used also throughout the halls for lighting. On each table is also a double desk light, which is also found in the more pretentious of the individual rooms where writing desks are placed.

In all rooms the dressing tables are provided with side lights. There is overhead lighting for general illumination and a reading light for those who find themselves unable to sleep or are forced by sickness to spend time in bed. The thoroughness and the careful attention to detail with which the lighting has been worked out are typical of all the power provision throughout the building.

Steam Generation

While the results of this careful engineering thought are evident everywhere, the best place to study this is, of course, in the basement where the power plant is installed and the arrangement of this plant is shown in Fig. 3. Approximately one-third of the area of the basement is taken up by the plant. The boilers are located in one corner and are 3 in number; the Park water-tube supplied by the D. D. Flanner Co. of Toledo, O.

Cross section of the setting used and the Detroit stokers which are installed under them, are shown in Fig. 4. Each boiler is rated at 250 hp. and is connected to 2 headers, one 10-in., the other 6-in. through automatic stop and check valves and gate valves. A Cochrane separator is also installed in each header to prevent the carrying of any water from the boiler room. Each boiler has a steam drum 54-in. in diameter, into which the feed line discharges. This drum has connections to the front and back headers and between these headers are inclined tubes.

The Detroit stoker has inclined side grates and a rocking bottom grate. The side grates to which the fuel is fed by screw conveyors carry it downward toward the center to the rocking sections at the bottom, which can either rock or dump as may be required.

The 10-in. steam header leads from the boilers to the engine room and supplies the 2 generating units and the elevator pumps. It is also cross connected to the 6-in. main. The 6-in. header runs through the engine room, a branch being taken off to the 75-kw. unit and on to supply steam for the kitchen. From the branch that leads to the 75-kw. unit, a line is taken to supply the ammonia compressor engines and the pumps in the refrigerating plant. From the 6-in. main in the boiler room, a 5-in. main is taken, which in the engine room is cut down to 2½ in. and is carried up for the supply of live steam throughout the building where required.

Back of the boilers is located the blowoff tank which receives the water discharged, relieves it of vapor and cools it before it goes to the sewer.

As will be seen by the key to steam pipes on Fig. 3, 4 systems are installed; the high-pressure pipes, exhaust steam, return steam from the heating system and high-pressure drips. Exhaust steam is sufficient for heating the building in most weather and also for heating water needed in the kitchen and bath rooms.

Feed Water System

Two house heaters shown in one corner of the engine room are Otis, made by the Stewart Heater Co., and are supplied with exhaust steam direct from the engines. The feed water is heated by a Cochrane open feed-water heater located in the front of the

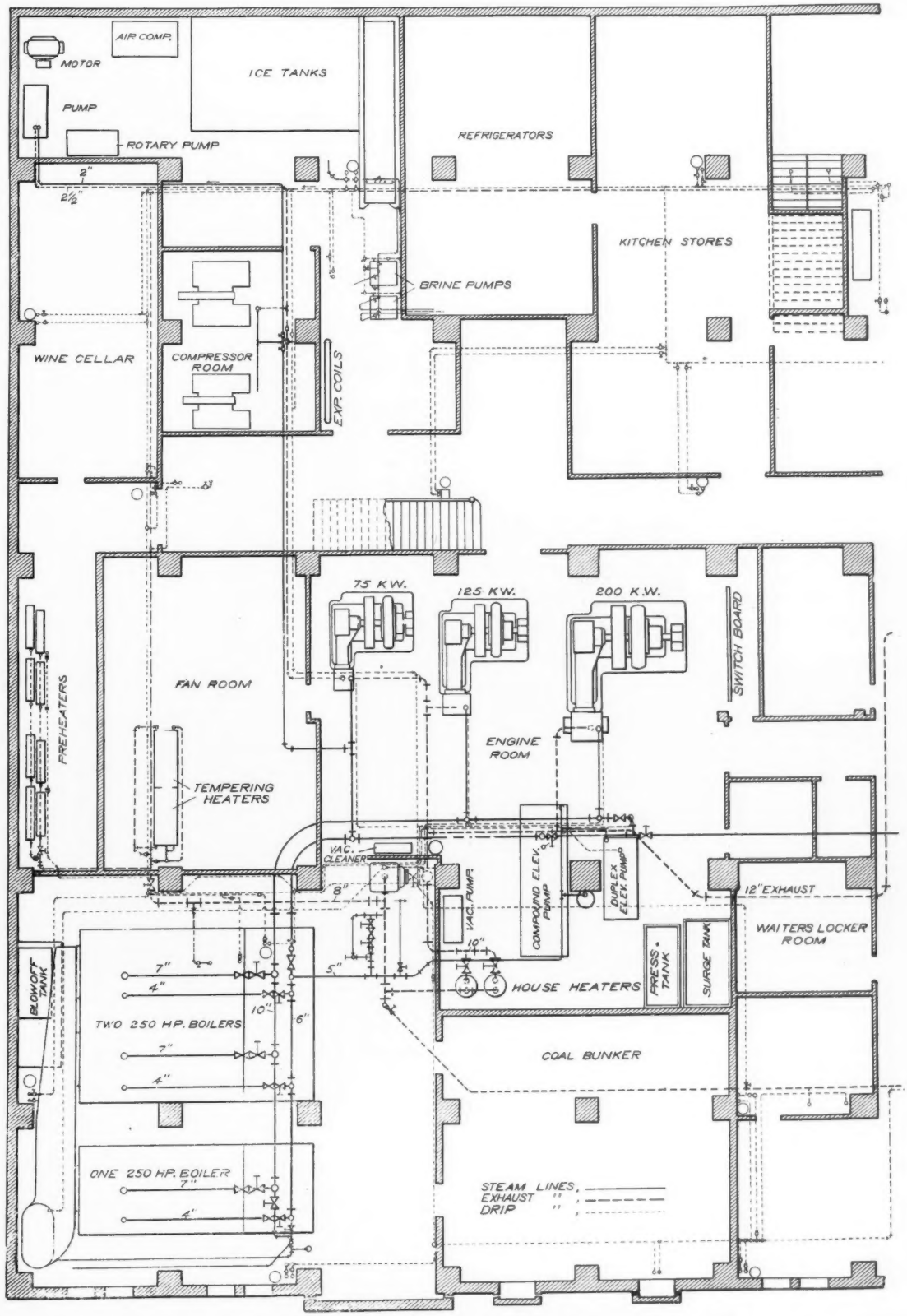


FIG. 3. PLAN OF HOTEL BASEMENT AND ARRANGEMENT OF POWER PLANT

boiler room. This has direct connection to the exhaust steam main; also the water trapped from the headers and from the separators over the engines is returned to this heater, from the top of which a vapor pipe leads to the roof. There is little vapor which gets away from this heater, however, as the exhaust steam is all utilized.

Vertical connections of this heater are shown in Fig. 5 A. The amount of steam which goes to the house heating system is controlled by thermostatic regulation and the condensed steam from the returns is brought back by a National vacuum pump located in the engine room, which is controlled by a governor so that the vacuum on the return is kept always the same.

Feed water for the boilers is controlled by Williams' regulators and pump governors and is supplied from the open feed heater by 2 Worthington duplex outside packed plunger pumps. A large and a small heater are provided, but the 2 are usually used in parallel.

Electric Equipment

Aside from the steam pumps in the engine and boiler room and the ammonia compressors in the refrigerating plant, all power used throughout the building is electric. Hence, it was necessary to provide large generating capacity.

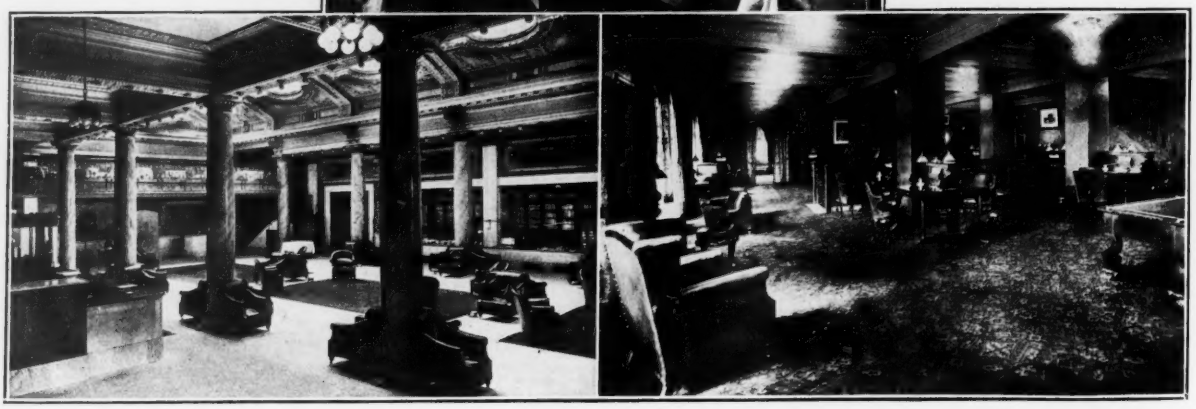


FIG. 2. ARRANGEMENT OF LIGHTING IN PRINCIPAL ROOMS; 1, MAIN LOBBY; 2, DINING ROOM; 3, WRITING ROOM

Three units are installed, each consisting of a Russell improved engine, direct connected to a Wood generator made by the Ft. Wayne Electric Works; from these generating units, current is taken to the switchboard and from there distributed to the motor and lighting circuits. The largest of these units is a 200 kw. generator, with 8 poles, running, at 250 r. p. m. The engine driving this is 18 by 18 in., with a balanced valve of the new type and controlled by a Rites governor. This engine is used from 4 p. m. until midnight, the current ordinarily supplied being 1,600 amperes at 115 volts.

At midnight the smallest unit of 75-kw. capacity with 6 poles, running at 275 r. p. m., is thrown on and carries an average of 600 amperes until 5 o'clock in the morning. It is driven by a 12 by 12-in. engine. At 5 o'clock, the third unit, a 125-kw. machine is thrown on and carries the load through the day. This has 6 poles, runs at 250 r. p. m. and is driven by a 14 by 14-in. engine.

Engines

The engines of these units are built with heavy frames and bases, with overhung crank and outboard bearing. The arrangement of the unit and foundation for the 200-kw. is shown in Fig. 6. The main bearing is in 3 pieces, a bottom shell and 2 side shells, which also come over the top of the shaft. The adjusting wedges run the full length of the bearing. Stuffingboxes for both valve and piston rods are designed with an inner sliding gland with a long neck which prevents any possible canting with consequent scoring of the rod. The valve is single, double ported and balanced, with a cover plate of the flat double-ended type known as the Sweet valve. To secure lightness and strength with a large bearing surface the piston is made hollow with a band of antifriction metal about the center to act as a shoe and 2 snap rings, 1 near either end.

The governor has a single swinging arm, the speed being increased by increasing the tension of the spring and decreased by adding weight to the end of the arm nearest the spring. On the 200-kw. unit the new style of engine with horizontal rocker for the valve motion is used, and on the smaller units the vertical rocker.

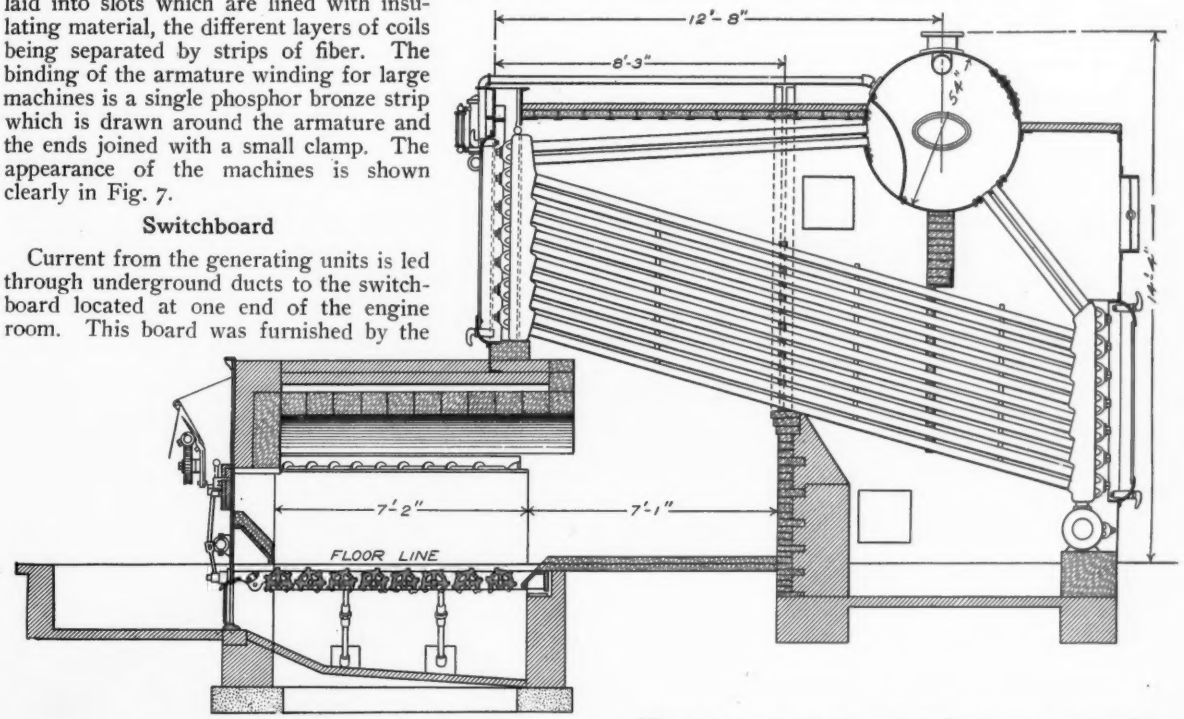
Generators

The generating units are of the regular MPL type of Wood apparatus for direct driving and have frames split horizontally, the lower halves resting on the unit base, the upper halves being bolted in place. Pole pieces are made entirely of sheet iron punchings riveted together, the poles being slotted to one-half their length and cast welded into the field frame after which they are finished to dimensions. The armature spider is keyed to the shaft and has the commutator mounted on an extension sleeve of the armature hub.

The core of the armature is made up of thin sheets of steel punched out, assembled and clamped in place between the 2 halves of the spider. The construction is well shown by an illustration in the article on Generators elsewhere in this issue. Spacing ribs are built into the core to form air passages. The armature coils are made of round copper on standard forms and laid into slots which are lined with insulating material, the different layers of coils being separated by strips of fiber. The binding of the armature winding for large machines is a single phosphor bronze strip which is drawn around the armature and the ends joined with a small clamp. The appearance of the machines is shown clearly in Fig. 7.

Switchboard

Current from the generating units is led through underground ducts to the switchboard located at one end of the engine room. This board was furnished by the Fort Wayne Electric Works, and, as shown in Fig. 8, consists of 3 generator panels and 2 feeder panels. Each generator panel is furnished with a circuit breaker, ammeter, voltmeter plug switch, rheostat and 3-pole main switch. The machines are, of course, arranged to be operated in parallel and current is fed to bus bars which are carried across to the feeder panels. The board is of black marble supported on angle iron frame work with rheostat mounted directly on the back of the board, the connections being as shown in the diagram, Fig. 8. Distribution of current is on the 2-wire system, but 3 wires are carried to all the panel boards as this makes the drawing of wire into the conduits easier and calls for smaller wire than if but 2 leads were used.



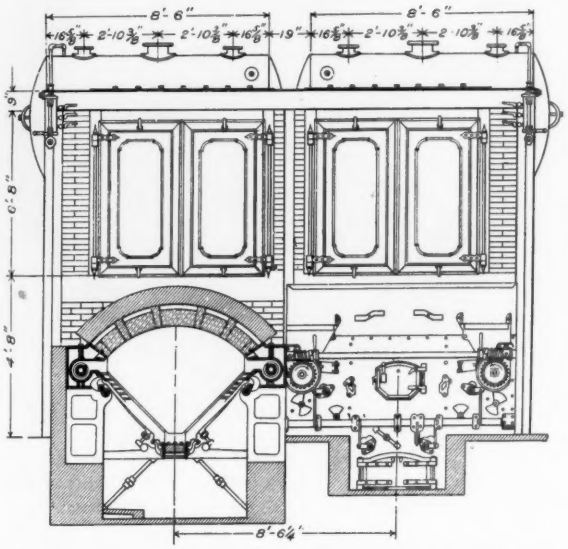


FIG. 4. SECTIONS OF BOILER SETTING AND STOKER

Thomson ammeters and voltmeters are used on the switchboard and General Electric circuit breakers, a common voltmeter being mounted on a swinging arm at the end of the board.

Lamps

For the lamps, different styles are used, according to the service needed. 40 and 60-watt tungstens constitute a considerable part of the lighting load. The hall lights are 60-watt Tungstens in stalactite globes, while the room lights are carbon filament and 40 and 25-watt tungstens. For the larger lighting units in ballroom and dining rooms, tungsten lamps are used with holophane shades and globes.

Motors

The principal motor load is for ventilating fans and elevators. The fans are located in a room at the end of the engine room and supply air, cooled or warmed, as may be desired, to the lower floor of the hotel. A fan is also provided which draws the air from between the upper and lower parts of the double floor which separates basement from the lobby, this provision being made to prevent the rising of heat from the kitchen and engine room to the floor above. On the roof are 2 10-hp. ventilating fans which draw the air from the kitchen and from the bathrooms, and a head through which air is drawn downward to the air washer in the basement.

All motors used in the plant are the Wood direct-current type EF. Those on the ventilating fans are of 10 hp. capacity running from 533 to 800 r. p. m. and drive American Blower Co. fans No. 120. These are for the ventilation of the rooms on the first floor. For

the engine room a fan No. 140 is driven at 775 r. p. m. by a 20-hp. motor, and for removing the air from between the floors a No. 80 fan is driven at 1,000 revolutions by a 5-hp. motor. All these fans are controlled

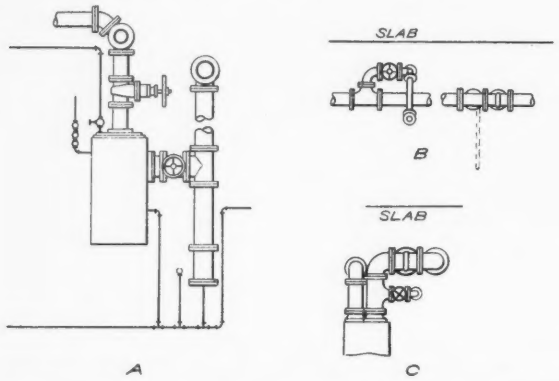


FIG. 5. DETAILS OF VERTICAL PIPE CONNECTIONS. A. FEED-WATER HEATER IN BOILER ROOM; B. CROSS STEAM CONNECTION TO ELEVATOR PUMPS; C. HOUSE HEATER STEAM CONNECTIONS

by Cutler-Hammer boxes located on the walls of the fan room.

To supply water for washing the air a size 3

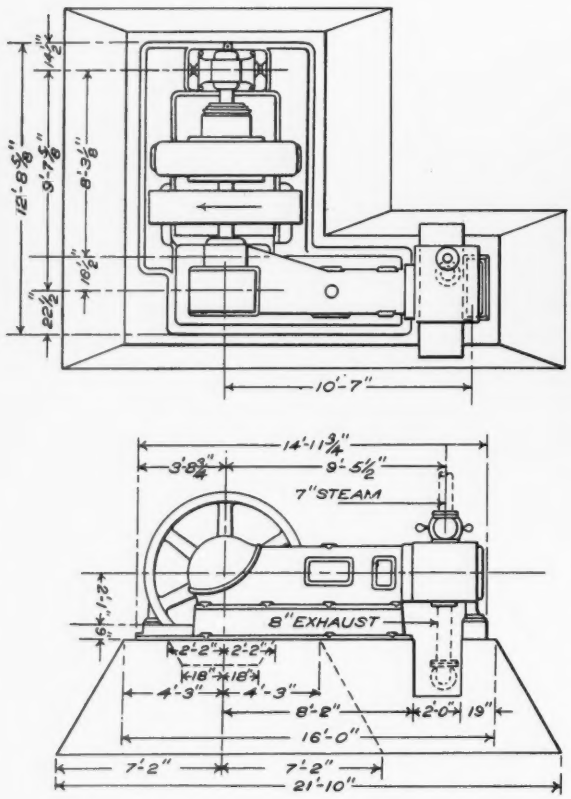


FIG. 6. SETTING OF 200-KW. GENERATING UNIT

Brooke's centrifugal pump is driven by a 15-hp motor running at 1,300 r. p. m. Small motors are used in various places for driving washing machines, the coffee mill, the ice chipping machine and other small power operations. The motors are 4-pole machines of the construction shown in Fig. 11. The field frame and pole pieces are cast in one piece, the poles being

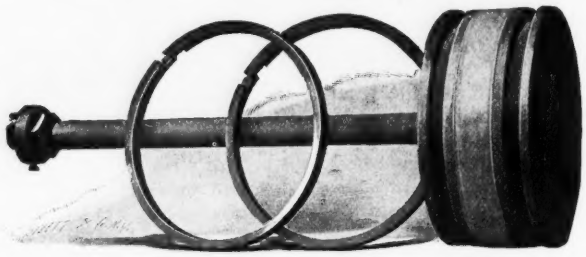


FIG. 7. PISTON AND RINGS USED IN ENGINES

built up separately and cast into the frame. The shaft is carried in the yokes which are bolted to the ends of the circular field frame. The fields are laminated, fitted with form wound interchangeable field coils.

Steam Uses

Steam is supplied to the kitchen for the steam tables where food is kept warm, for plate warmer ovens, for the coffee urns and tanks, and for dish-washing machines. Cooking is performed, of course, largely by the use of gas. The elevators are of the

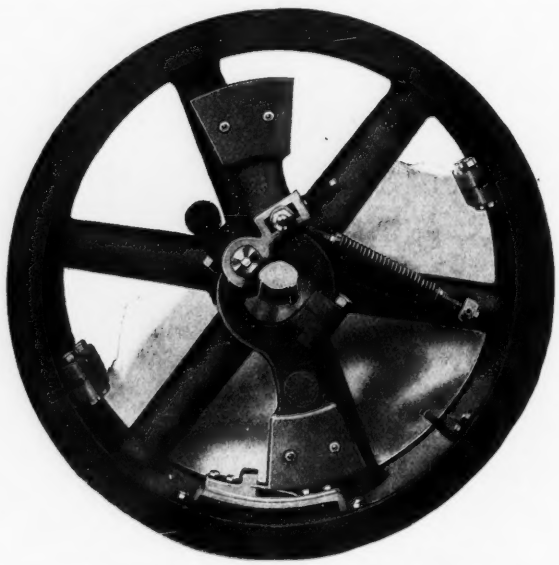


FIG. 8. GOVERNOR USED ON "RUSSELL" ENGINES

hydraulic plunger type, water being taken from the surge tank and forced into a pressure tank, the cushion in this tank being supplied by air compressed in the upper part.

Two elevator pumps are installed, both made by the Laidlaw-Dunn-Gordon Co. One of these is a tandem compound duplex with cylinders 12 and 18 by 10 by 18 in., having outside packed plungers. The second pump is a simple duplex 14 by 10 by 18 in. Both these pumps draw from a common connection with the surge tank, an air chamber being installed on the suction to take up water hammer.

In the tank from which the elevators are supplied the pressure is 120 lb. The large pump runs prac-

tically all the time and a reduction of 10 lb. in the pressure tank will start both pumps running. Both are kept constantly in commission in order to keep them in good condition and also this arrangement cuts down the piston speed on the No. 1 or compound pump and gives a more uniform speed to the elevators when several happen to be running.

The steam connection to the elevator pumps is a crossover and is arranged so that steam may be taken from the small header or from a 5-in. pipe which leads directly from the boilers, the crossover connection being as indicated on Fig. 5-B. The vacuum pump is also connected to the 5-in. main which leads direct from the boiler room. On a pillar between the 2 elevator pumps is placed a Westinghouse air compressor which furnishes air for cleaning about the engine room.

Sundry Equipment

The vacuum cleaning system consists of a Root exhauster driven by a 10 hp. Wood motor located near the door from the engine room to the boiler room. This maintains a vacuum of 12 in. at the exhauster and draws the air through water in the bottom of the receiver tank, which tank is piped to 4 risers that go up through all floors, connection plugs being located on each floor, and sections of hose being furnished so that the vacuum cleaner heads may be used in any part of the building.

The traps used for carrying off drip from the separators above the engines and from the main headers are the Bellvac traps manufactured by the Consolidated Engineering Co., of Chicago, which company also installed the vacuum heating system.

Water for the hot water service is supplied by 2 10,000-gal. tanks located in the roof and feeds through the heaters by gravity to the hot water piping system of the house.

A Liberty oil filter is provided for cleansing the oil after it has gone through the engine and dynamo bearings. The engines are lubricated by a special

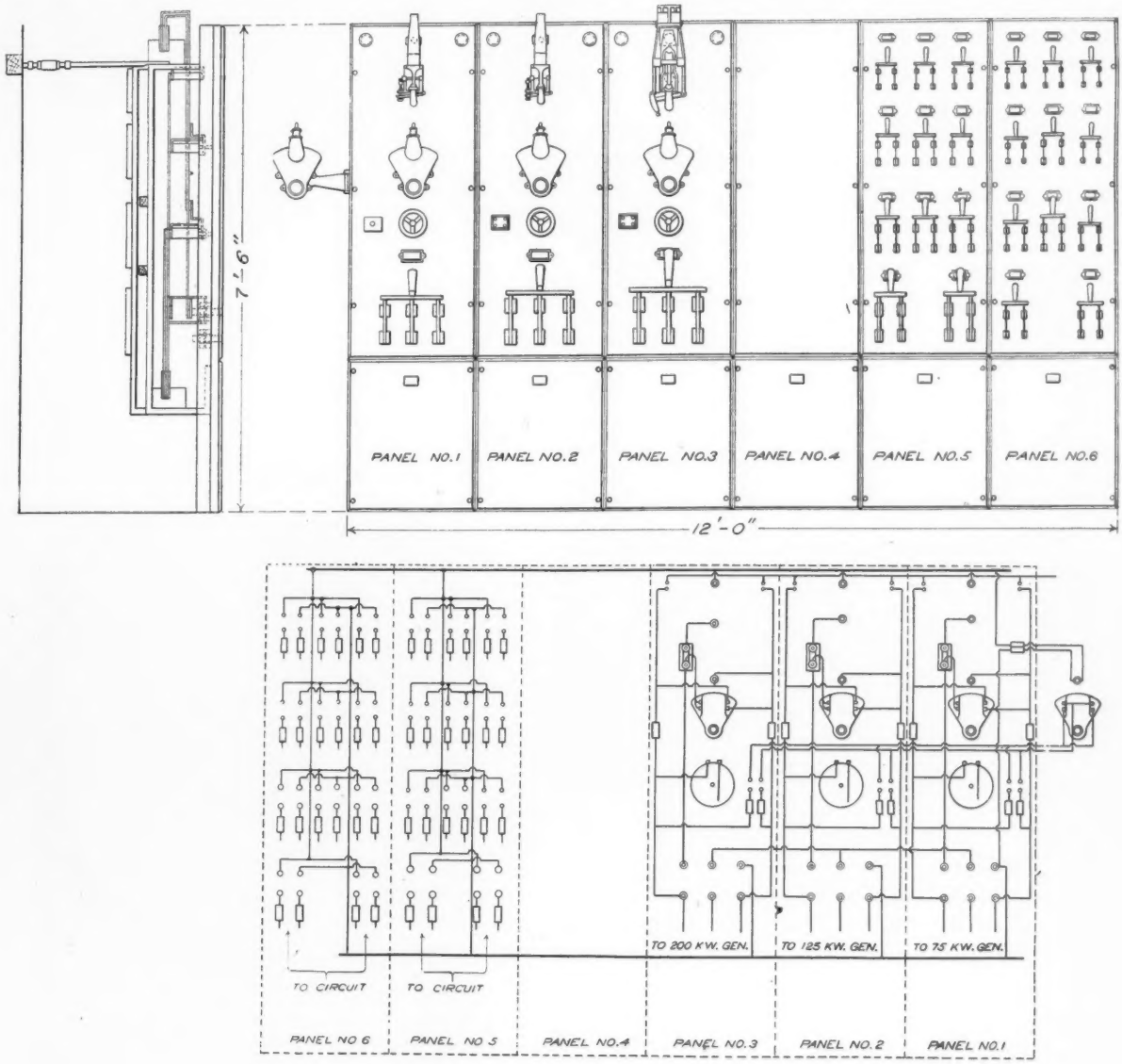


FIG. 10. SWITCHBOARD FRONT AND END, AND CONNECTION DIAGRAM

self-oiling system while the bearings on the dynamos are ring oiled and the cylinders are fed by Hills-McCanna force feed pumps.

ment of George S. Mills, architect, Toledo, and the present fine condition of the plant reflects great credit on the chief engineer in charge, M. C. Hoard.

FIG. 11. PARTS OF "WOOD" MOTOR USED AND DETAIL OF BRUSH HOLDER

Ice and Refrigeration

Across the hall from the engine room and near to the refrigerators and store rooms is located the ice and refrigeration plant. This consists of 2 Brown-Cochran compressors direct driven by Atlas simple engines. One of these is 10 tons capacity and the other 12 tons. The refrigerating medium used is carbonic anhydride, the gas being compressed from 20 atmospheres to 60 atmospheres.

The expansion coils are located on the wall of the room and the brine coils are carried through the different refrigerating compartments and through the ice tanks. Coils of the gas condenser are cooled by water pumped from a deep well.

This water is raised by an air lift system to a concrete reservoir in the floor of the ice room and from this reservoir is pumped by a Knowles single cylinder 14 by 8 by 12-in. pump to tanks on the roof. For the air lift compressed air is furnished by a Rand 2-cylinder belted compressor driven by a link belt connection from a Wood motor through a countershaft.

As a second means of sending water to the roof tanks, a 20-hp. Wood motor is direct connected to a Worthington centrifugal turbine pump, the discharge from either this pump or the Knowles on the way to the roof passing through the sweet water cooling coils and the gas condenser cooling coils.

Brine circulation is maintained by 2 Deming triple power pumps with pump cylinders 5 by 6 in., made by the Deming Pump Co., each driven by a 5-hp. Wood motor at 650 to 975 revolutions. Brine coils are carried through the meat and vegetable refrigerating rooms and also through a garbage storage room, so that all odor is avoided.

The ice tank holds 121 cans and the distilled water for filling the ice cans comes from the exhaust steam returns through a reboiler, then through a cooler and 2 charcoal filters from which it passes to the sweet water tank, where it is cooled and from which it flows to the cans through a Burns can filler.

The planning of the installation as well as its carrying out was in charge of the engineering depart-

NO FUNNEL ON A MAN-O'-WAR and no smoke to indicate her whereabouts is an anomaly. Yet that will be the case with the British cruiser Indefatigable for which

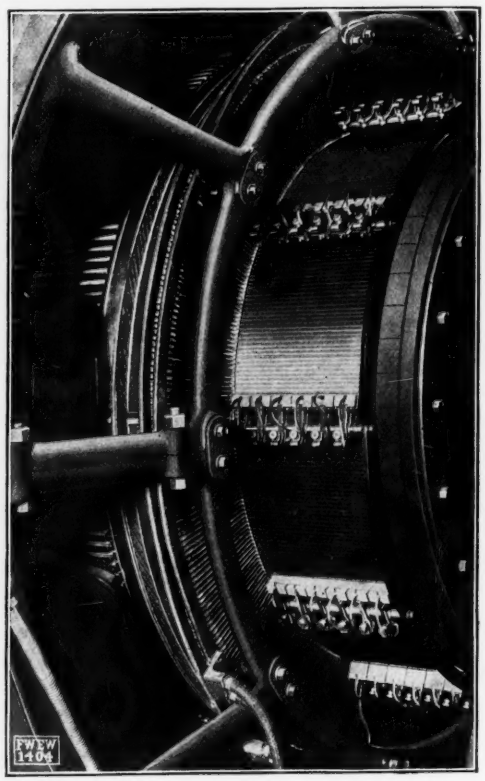


FIG. 12. DETAIL OF "WOOD" GENERATOR

the keel has just been laid. Above the upper deck will be only gun turrets, 2 masts and the bridges. The motive power will be from gas engines exhausting outboard.

PROPER DISTRIBUTION OF LIGHTING

BECAUSE of the fact that a dim light is difficult to read by we are apt to think that the stronger the light the better it is, but this, on a little thought, will be found untrue. One of the most difficult and trying things for the eyes is to read with the paper in bright sunlight, particularly if one is facing the sun, while it is not at all difficult to read in a dim light, if the light does not shine directly into the eyes.

Modern science has shown that even diffusion of light is what is needed rather than great intensity and that the thing to be avoided is spots of very strong light in connection with rather dim lighting. The eye attempts to adjust itself to 2 conditions, first, the dimness of the general lighting, second, the strong spots, the dim light requiring a wide open pupil and the strong spots a contracted pupil. We are now, therefore, distributing our light and covering up the bright source of lighting so as to save this eye strain. The methods used are ground glass bulbs, opal globes and lights set high above the line of vision with diffusing shades.

The latest system, which carries this to the extreme, is the indirect system of lighting, in which

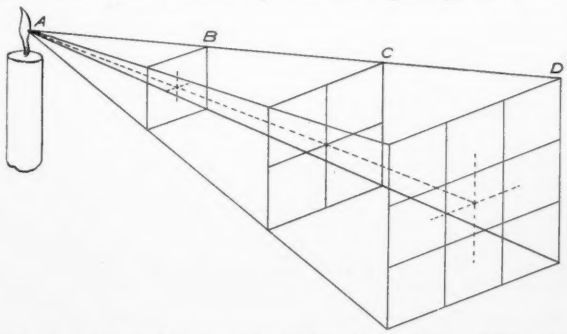


FIG. 1. VARIATION OF INTENSITY OF LIGHT WITH DISTANCE FROM SOURCE

the light from the lamps is thrown upward upon light colored ceilings, from which it is reflected downward, the reflectors being opaque so that no light is thrown downward from the lamps. As some light is lost in every reflection, it is evident that this is not the most economical system, but it gives a very pleasing light and where cost is not of first importance it is well worth considering.

Lighting Intensity

There is, of course, a low limit of intensity for the lighting in any work and the measure of lighting intensity by which this is gaged is the candle-foot, which is the amount of light falling on a surface at a distance of 1 ft. from what is known as a standard candle. This standard candle is an inheritance from the old days when that was the only method known of getting a steady light.

Although we still use this unit, the laboratory standard now taken for comparison is a lamp of a certain sized burner and certain length of flame; burning amyl acetate, a special kind of alcohol product; all which has nothing to do directly with the subject in hand because the standard 16-candlepower electric incandescent lamp is the practical unit of comparison in all lighting work.

Intensity of light varies inversely as the square of the distance from the source of light, as indicated in Fig. 1. For instance, at 1 ft. from a 16-candlepower lamp the intensity would be 16 candle-feet, while at 4 ft. from the lamp it would be one-sixteenth that, or 1 candle-foot.

To give an idea of the intensity needed for different operations, 1 candle-foot, that is 4 ft. from a 16-candlepower lamp, will give easy reading. For general illumination an intensity of 0.5 candle-foot on a level 3 ft. from the floor is about a minimum. A bright moonlight night will have an intensity of 0.03 candle-foot, while bright sunlight reflected from white clouds will give an intensity of 20 candle-feet.

Incandescent Lights Needed

The easiest way to proportion lighting for a given space is by allowing a certain number of candlepower per square foot of floor surface and this will answer

FIG. 2. INDIRECT LIGHTING BY REFLECTION FROM CEILING, 3.5 SQ. FT. PER CANDLEPOWER

nicely so long as the lights are kept at about the usual distance from the floor. For ordinary house lighting, with the lights placed 8 ft. from the floor, 3 to 4 sq. ft. of floor surface per candlepower will give a moderate light, and 6 sq. ft. per candlepower will give a light suitable for reception rooms.

Except for decorative effect, the incandescent light is not economical for lighting large areas such as shops and halls. For this purpose arc lamps, the Nernst or the Cooper-Hewitt mercury vapor lamp, are adapted, although with the coming of the high power tungsten lamp, which has a large light efficiency, the incandescent lamp has largely extended its field of usefulness. If well distributed, the light in halls will be good with 3.75 sq. ft. of floor surface per candlepower. This means a number of units well spaced through the room and with arc lamps mounted at 20 to 25 ft. above the floor and Nernst or Cooper-Hewitt lamps at 10 ft. A brilliant lighting is secured with an allowance of 2.5 sq. ft. per candlepower.

For shops and factories, evidently the general il-

lumination need not be strong, and yet it is necessary that at the points where work is being performed, there should be a good intensity. The lights which furnish this intensity must, of necessity, be incandescents but should be shaded so that they are not seen by the eye.

Arc Lamp Lighting

Arc lighting is perhaps the most difficult to proportion because each lamp gives a large amount of light and this results in bright spots and dark spots. An idea of arrangements which will give satisfactory results may be gained from the following cases: The candlepower of arc lamps varies so greatly that it is usual to reckon the amount of lighting by the watts per square foot of floor surface rather than candlepower. For dry goods stores, with the lights hung at 9 ft. from the floor, 1.25 watts per square foot gave satisfactory results. For an erecting shop with the lights at 40 ft. from the floor, 0.63-watt per sq. ft. was satisfactory. For a drafting room with lights at 10 ft from the floor and no other illumination, 2.1 watts per sq. ft. was needed. For an office with lights at 11 ft., 2 watts per sq. ft. was sufficient. For a jewelry store with lamps hung at 12 ft. from the floor, 0.83-watt has been used, but this was supplemented by lights in the showcase to make the goods stand out. For a stock yard where castings, flasks and materials were stored, with lights hung at 50 ft. from the ground, 0.5 watt per square foot was sufficient.

Putting this in somewhat regular form and reckoning the watts at the terminal of the arc lamps, it is found that in ordinary placing of lights for shoe stores and others where strong lighting is not important, and for shops with high roofs and no obstructions in the form of belting, 0.75 watt per square foot; for shops with low roofs and with belts to cut off the light, 1 watt per square foot; for department stores and others where colored fabrics must be handled, 1.1 watts per square foot; for mill lighting, 1.2 watts per sq. ft.; for office lighting, 1.5 watts; for drafting rooms, 1.75 watts per sq. ft. These values all imply that the lights are used to the best advantage, so placed that they will give even distribution and provided with proper reflectors and shades to avoid intense glare and the waste of light by having it thrown upward; also special lights for machines or desks as needed.

Light walls and ceiling call for less lighting than dark ones, the dark wall needing 3 times the light of a white wall, and walls which are comparatively smooth will need less light than those which are rough and broken with paneling. The effect of the ceiling coloring and surface on the light needed is greater than that of the walls, because whatever light is thrown upward must be again reflected down in order to be useful.

It is evidently cheaper to bunch incandescent lamps in a chandelier than to distribute them, as it calls for less wiring and less cost of fixtures, but the distributed lights will give a more even illumination where any large space is to be covered. For the rooms of a dwelling or office building the 2 or 3-light chandelier is, however, satisfactory.

Where general illumination is desired, some light must be allowed to pass upward or a gloomy effect is produced, but where the light is to be used entirely for reading or working as much of it as possible should be thrown downward in order to be useful.

If the intensity of lighting given above is used and the first principle, that uniform lighting without spots of high intensity must be secured is observed, the illumination in any room or building will be found satisfactory.

INCANDESCENT ELECTRIC LAMPS AND THEIR PROPER USE

MOST widely distributed of all is some form of incandescent lamp, and the 3 principal types now on the market are the carbon, the tantalum and the tungsten. In the carbon filament, there are 3 species, the low economy lamp, which takes 3.5 or 4 watts per candle power, the high efficiency lamp, which takes 3.1 watts per candlepower and the "Gem," which has a special treated carbon filament.

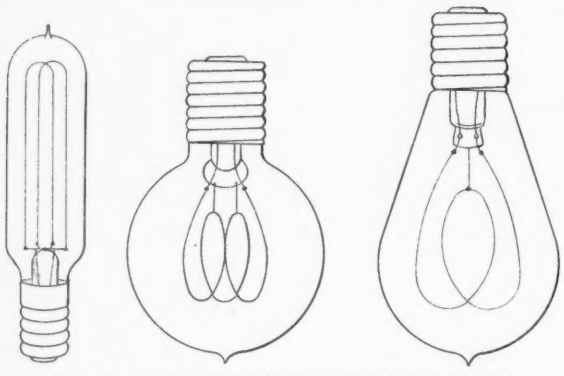


FIG. 1. TYPES OF CARBON FILAMENT LAMPS

All these, however, have the carbon characteristics in some form, while the tantalum and tungsten lamps give a light comparable with the Welsbach gas mantle, and have the filament made of rare metals instead of carbons. These filaments are of lower resistance than carbon and are therefore thinner and longer for the same voltage and are brittle, so that they must be handled with some care. They also have the characteristic of metals, that with high temperature, the resistance increases, so that a variation of voltage does not affect the candlepower nor the light of the lamp with the metal filament lamp, as it does with the 3 carbon lamps.

TABLE I. COMPARISON OF COST AND CANDLEPOWER OF INCANDESCENT LAMPS

	CARBON			GEM	TANTALUM	TUNGSTEN	
CANDLE POWER	16	16	32	18	20	32	48
WATTS PER C P.	3.5	3.1	3.1	2.8	2.0	1.25	1.25
TOTAL WATTS	56	50	100	50	40	40	60
HR. LIFE	1000	500	500	1000	800	800	800
COST OF LAMP ¢	20	20	30	25	46	1.01	1.28
POWER COST PER 100 HR. AT 10 ¢ PER K.W. HR. ¢	56	50	$1.	46	40	40	60
LAMP & POWER COST PER 100 HR. ¢.	58.1	54.1	$1.06	48.8	45.75	52.75	76
LAMP & POWER COST PER 100 CANDLE HR. ¢	3.94	3.68	3.60	3.29	2.48	1.78	1.72

High Incandescence

With any type of lamp, greater light efficiency is secured by burning at what is called a higher incan-

descence, that is, a higher temperature of the filament. This is because the high temperature gives more of the blue or violet rays which go to make up the white light of daylight and these rays are the ones which are effective in giving illumination. The red rays are nearer to the heat rays and less effective for lighting. As high efficiency means burning the filament at a high temperature, it, of course, means a shorter life, so that the cost of renewing the lamp is higher for the 3.1 watt carbon filament than for the 3.5 watt and comparison shows that unless the cost of current is greater than 1.6 cents per kilowatt hour, the 3.5 watt

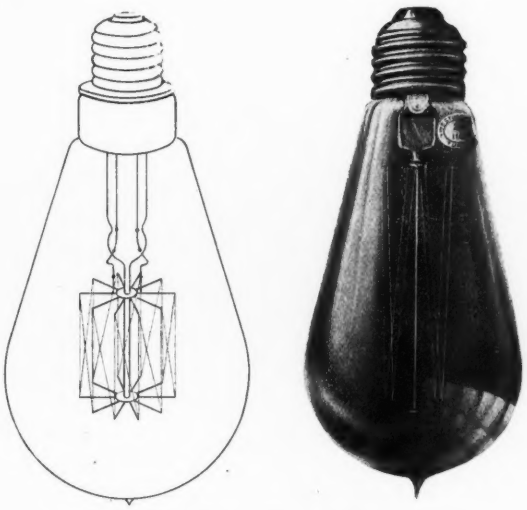


FIG. 2. TANTALUM INCANDESCENT LAMP
FIG. 3. WESTINGHOUSE 25-WATT TUNGSTEN LAMP, 20 CANDLEPOWER

lamp is cheaper in the long run than the 3.1 watt where the cost of renewing the lamp is taken into account.

Comparison of Incandescent Lamps

Table 1 gives a comparison of the properties and cost of burning of the different styles of incandescent lamps and shows that the watts per candlepower for a Gem metallic filament will be 2.8, for a tantalum 2, and for the tungsten 1.25.

Where there is vibration, the carbon filament is the only one which will stand for a long time. Where but a small amount of light is needed per unit, as in sign lighting, in decorative border lights and for hallways, the carbon again comes to the front as the tungsten and tantalum are not made in small candlepowers for 110-volt service. It is also well to remember that in an isolated plant where the generating units have plenty of capacity and the extra cost of electrical energy for the 3.5-watt carbon filament lamps is the only extra cost of burning, the values as given in this table for the total cost per 100 hours are not applicable since this cost is based on 10 cents per kilowatt hour and the fuel cost ought not to run over 0.5 cent per kilowatt hour.

Tantalum and tungsten lamps being of higher candlepower must be set farther apart than the carbon filaments, hence unless shades are used so as to diffuse the light and even up the illumination there will be greater difference between the light spots and the dark spots than with the carbon lamps. On the other hand, both of these lamps burn with a white light very much resembling daylight and are, therefore, easier on the eyes than the carbon filament lamp.

It makes a good deal of difference what kind of a carbon filament is used and how it is placed with regard to the amount of illumination secured from it.

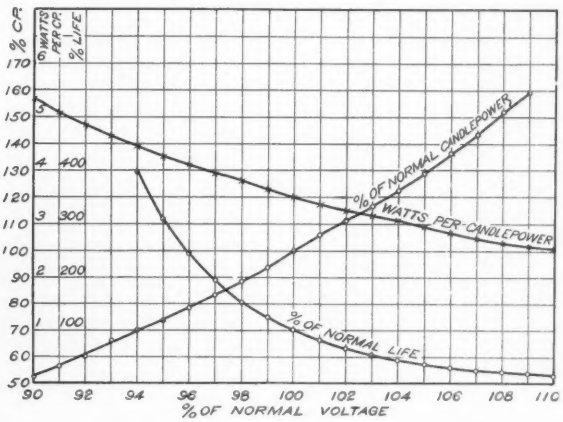


FIG. 5. EFFECT OF VOLTAGE VARIATION ON LIFE, CANDLEPOWER AND ENERGY USED IN A 3.5-WATT LAMP

Several forms of carbon filaments are shown in Fig. 1. When light is wanted in a horizontal plane, that is, at the sides of the lamp or when the lamp is to be set horizontal or at an angle, the long slender filament is better and the 2-loop type usually gives more uniform distribution in all directions. Where the lamp is to be hung vertical and the light is wanted below the lamp, evidently the filament with 3 coils at the end will give better results. In any case, where the light is wanted below the lamp, some form of reflector or diffuser is needed, as shown in the section on the use of shades and fixtures.

The Linolite Lamp

One form of carbon filament particularly adapted for showcase and desk lighting is called Linolite and is made by the H. W. Johns-Manville Co. This has the filament extended in a straight line instead of a loop so that the light from the entire length of the filament can be thrown in one direction by a curved reflector placed at one side of the tube. It has the properties of any carbon filament lamp and is particularly well suited for the purpose for which it is designed.

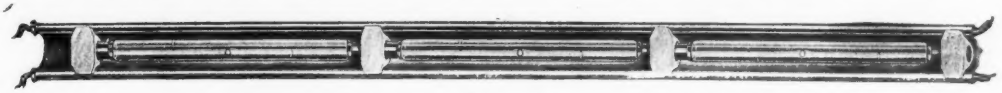


FIG. 4. A SECTION OF LINOLITE REFLECTOR WITH LAMPS IN PLACE

One advantage of the tungsten lamp is that it will maintain its full initial candlepower practically to the end of its life, while the carbon filament lamp drops off to about 80 per cent of its efficient candlepower by the time it has burned 1,000 hr. This 80 per cent is taken as the smashing point or the point at which the

lamp should be taken out of service, as when the light falls below 80 per cent of the initial candlepower the cost of energy to do the lighting becomes excessive.

A disadvantage under which the carbon filament lamp labors also is its variation of candlepower and of light if the voltage changes from the normal value. Experiment has shown that an increase of 3 per cent above the voltage for which a lamp is intended will cut its life in half, while an increase of 6 per cent will cut its life to one-third the normal value. This effect is greater on the 3.1-watt lamp than on the 3.5-watt. Figure 5 shows the variation of light, candlepower and energy used, with voltage.

In order to use a 3.1-watt lamp, the very best of regulation must be had or the lamp will be short-lived; if the variation is, say, 2 per cent, the 3.5-watt lamp will serve well, while if the regulation is poor a 4-watt lamp must be used even at greater energy cost in order to get the renewal cost within reasonable limit.

On acount of the intense brilliancy of the filament, it is quite important when using tungsten lamps that the globes should be frosted if the lamps are so placed as to come in the line of vision, that is, where the lamp will be seen by the eye. Of course, if the lamps are placed high and reflectors used, the bulbs used need not be frosted. As an example of what can be done by the use of tungsten lamps with the proper prismatic reflectors, a store in St. Joseph, Mo., has recently been lighted by such a combination, giving an illumination of 4 candle-feet at the counters with an energy expenditure of 0.82 watt per square foot of floor surface. This was with 60-watt lamps and the bowl Holophane prismatic reflectors.

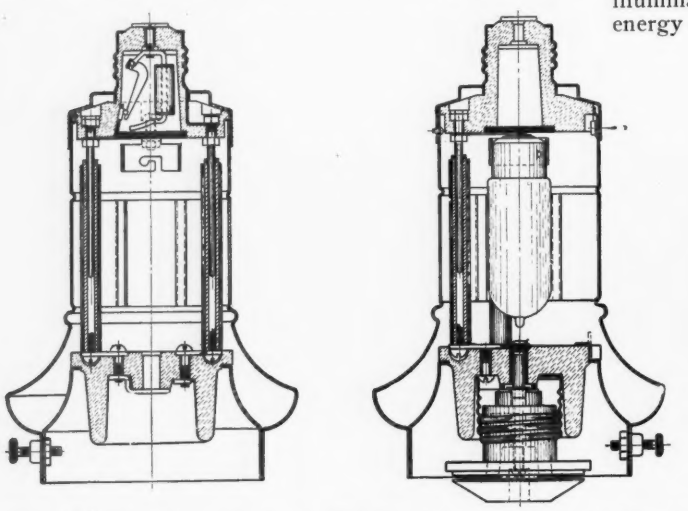


FIG. 6. SECTIONAL VIEWS OF NERNST SINGLE GLOWER LAMPS

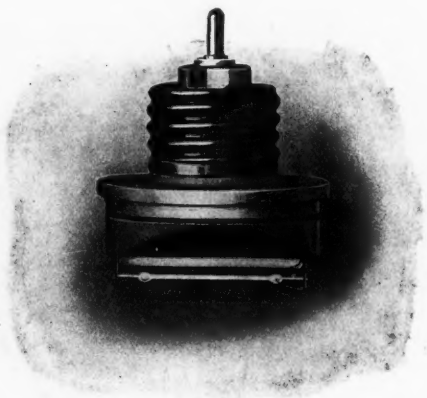


FIG. 7. NERNST SCREW BURNER WITHOUT GLOBE

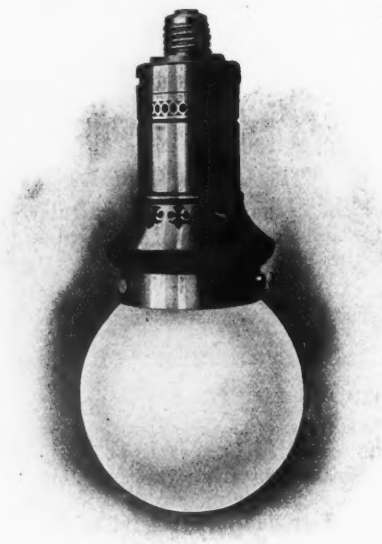


FIG. 8. SINGLE GLOWER NERNST LAMP COMPLETE

The Mercury Vapor Lamp

The mercury vapor or Cooper-Hewitt lamp is a special incandescent form in which the luminous medium is vapor of mercury contained in a glass tube. The tube is set on an angle with the horizontal and the bottom electrode is a small pool of mercury while the electrode at the top end of the tube is an iron terminal. The tube is exhausted of air and, on starting, current is set up either by tipping the tube so that the mercury flows down and makes contact with the iron point, or by passing a quick-break spark through the tube, which vaporizes sufficient of the mercury to fill the tube with vapor.

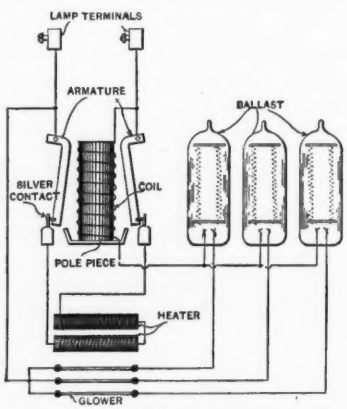


FIG. 9. DIAGRAM OF NERNST 3-GLOWER LAMP CONSTRUCTION AND CONNECTIONS

This lamp is available for direct and for alternating current circuits at 100 to 120 volts. The length of

tube required at 100 volts is 43 in. and at 120 volts 49 in. The diameter of the tube is 1 in. and the current used from 3 to 3.5 amperes, giving at 120 volts 750 candlepower. The average life of the lamp is about 1600 hr. Frequently in order to get more even distribution with smaller units, 2 55-volt lamps are put in series across a 110-volt system, the arrangement being as shown in Fig. 10, where the lamps are arranged for tipping in order to start. A steadying resistance and inductance are put in series with each lamp in order to take care of variations in voltage and avoid flickering in the light.

This lamp is easy on the eyes, but on account of the violet green color is not adapted for rooms where

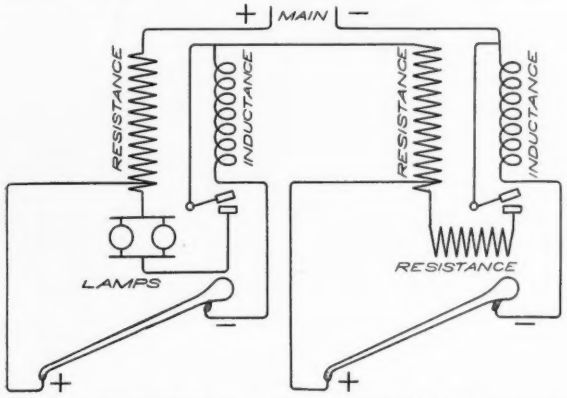


FIG. 10. ARRANGEMENT OF COOPER-HEWITT 2-LAMP UNIT

goods are to be displayed. It is evidently well fitted for photographic purposes, for shop use, for drawing rooms and for offices, as small details can be seen with great clearness.

The Nernst Lamp

The Nernst lamp is a form of incandescent having a glower which is an enlarged filament burning in air,

TABLE II. ENERGY AND POWER OF NERNST LAMPS

GLOWERS	VOLTAGE	AMPERES	WATTS	CANDLEPOWER	
1	110	0.6	66	48	MEAN LOWER HEMISPHERE
1	220	0.4	88	73	
1	110 & 220	1.8 & 0.5	110	98	
1	110 & 220	1.2 & 0.6	132	156	MEAN 0 TO 60 DEGREES
2	220	1.2	264	345	
3	220	1.8	396	528	
4	220	2.4	528	745	

made out of rare earths compounded according to the best results of experiments made by the manufacturer. This glower is heated by the passage of the current and gives off light in the same way that the mantle of a Welsbach incandescent gas burner operates.

The glower is not a conductor when cold and must, therefore, be heated in order to let current pass so that it will become incandescent. This necessitates a heater which will be cut out after the glower is in operation and as the changes in voltage or fluctuations would cause variation in the light given off by the lamp and as the resistance of the glower would decrease with the amount of current passing through, it is necessary to put in series with this glower some form of steadying device or ballast and iron wire is commonly used for this purpose.

All forms of the Nernst lamp work on the same principle but differ in arrangement and details, depending on the number of glowers used. For the smaller lamps a single glower is used and for the larger ones 2, 3 and 4, as may be desired. The 1-glower lamps, such as shown in Fig. 6, are made to screw into an Edison socket and have mounted in the Edison base the cutout which throws the heater out of use after the glower comes into use.

Figure 6 gives sectional views in 2 directions of the 1-glower lamp, the connection arrangement of which is indicated in Fig. 9, which shows the connection diagram for a 3-glower lamp, the operation being clear without explanation. Current will flow through the silver contact and the coil from the heater until the glower becomes warm enough to permit the passage of current, when the current passing through the glower energizes the pole piece of the upper magnet, and attracts the 2 vertical armatures at the side breaking the silver contacts and cutting out current from the heater.

Ballast wires, as indicated, are mounted in glass tubes to protect them from rapid burning out. These ballast tubes are mounted for the 1-glower lamp in the porcelain, which is shown below the Edison base in Fig. 6, and are above the screw receptacle into which the burner is placed.

This burner is shown in Fig. 7 and has on the bottom surface the glower and a flat wafer heater instead of the coil used in some of the older types of Nernst lamps. This heater consists of a wire covered with porcelain and bent back and forth along the surface of the porcelain base; current may pass through this just above the glower. The life of one of these screw burners is from 600 to 800 hr., that of the heater 300 hr., of the ballast 15,000 hr. The 1-glower lamp is made in sizes of 66, 88, 110 and 132-watts, the 2-glower, 264 watts, 3-glower, 396 watts, and 4-glower, 528 watts. Table 2 gives the sizes and characteristics of the different Nernst lamps.

To give a basis of comparison of the performance of Nernst lamps with the other forms of incandescent, the 66-watt lamp gives a candlepower for 1.38 watts and the larger sizes give a candlepower for 1.2 watts. The cost for 100 candlepower-hours for comparison with the values in table 1, is for the 4-glower unit 1.121 cents, which for a similar amount of illumination compares with 1.54 cents for a tungsten cluster and 1.423 cents for the direct-current enclosed arc.

LIGHT DISTRIBUTION

EVIDENTLY the useful light is that which is thrown downward, if for reading or detail work directly downward, as the light is placed over the machine or desk; if for general illumination, anywhere below the horizontal because the space between lamps must be illuminated as well as that directly under the lamp.

Distribution from a lamp without any means of directing the light is not such as to give good results. Figure 1 shows in what is called an illumination diagram the way in which the light spreads for different kinds of filaments. 1 is for the double loop style, 2 is for the single loop, and 3 for the flat end. Even at best this gives altogether too much light going upward.

In explanation of these curves, the distance from the center out on any radius gives the relative candlepower of the light in that direction and the curves shown in Fig. 1 indicate that about as much light is thrown upward as goes downward. The condition evidently is not good economy.

Reflectors

To throw the light downward requires the use of

reflectors or shades and by the proper shaping of the reflectors or by the use of prismatic diffusing shades any desired distribution may be secured. The cheapest and most common form is the metal reflector, with painted surface. The distribution with this depends entirely on the shape of the reflector and no light can

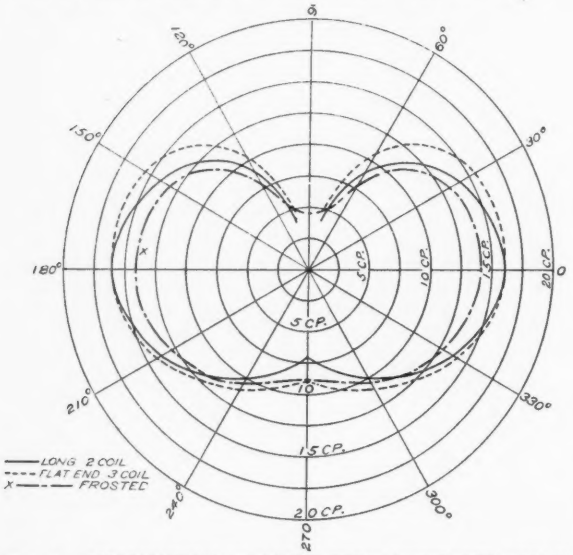


FIG. 1. DISTRIBUTION OF LIGHT FROM UNSHADED INCANDESCENT LAMPS

pass, of course, above the lamp, so that where general illumination is desired this does not give good results unless the reflectors themselves be near the ceiling.

It is usual to drop lights somewhat below the ceiling on fixtures, since this gives much greater illumination near the floor. The reason for this, as explained

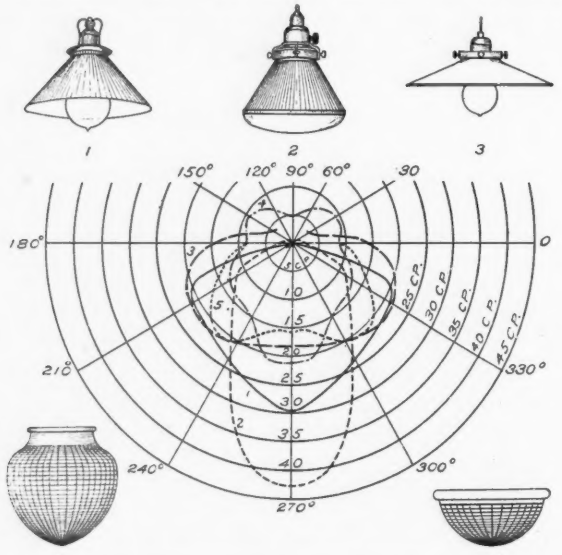


FIG. 2. LIGHT DISTRIBUTION WITH METAL SHADES AND WITH PORCELAIN REFLECTOR

under the head of Principles of Lighting, is that the intensity of the light decreases as the square of the distance from the light. For lighting of a desk or machine a conical reflector gives the best concentration, the shape depending on the area over which it is desired to spread the light. For general illumination a flat or slightly curved reflector is the proper form.

A form of enameled steel shade, made by Harvey Hubbell, Inc., is shown in Fig. 3. As shown this is made with a specially deep neck as it is intended for use with the tungsten lamp, which has a skirt above the filament; if set in the ordinary shade this skirt

FIG. 3. HUBBELL ENAMELED STEEL SHADE AND SOCKET FOR TUNGSTEN

throws the light too far below the reflecting surface. This particular make of shade has a white enameled surface which is easy to keep clean, does not break and reflects the light well. It will not, of course, allow any light to pass through, so that for use where the lights are hung low and the ceiling is dark, the upper part of the room would be somewhat gloomy. The porcelain shade gives good reflection and also permits a certain amount of light to pass through to the ceiling, but it

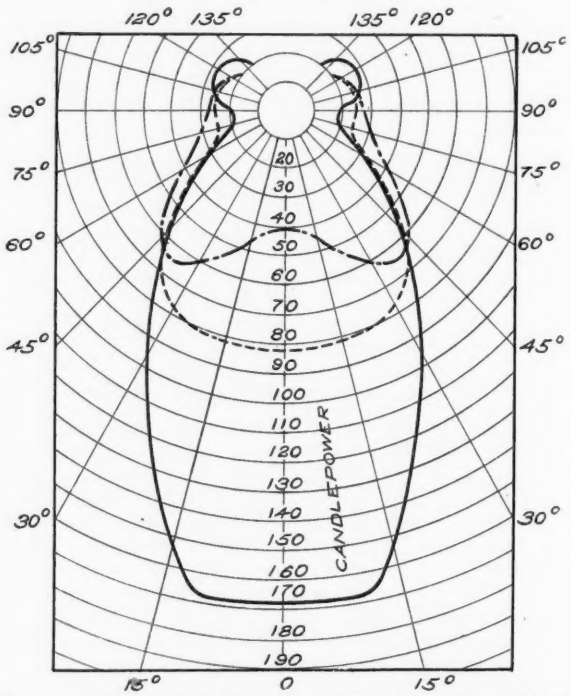


FIG. 4. LIGHT FROM PRISMATIC REFLECTORS AND SHADES INNER CURVE, EXTENSIVE REFLECTOR; MIDDLE CURVE, CONCENTRATING REFLECTOR; OUTER CURVE, FOCUSING REFLECTOR.

does not soften the light at all to the eye. The glare of the lamp filament is still present.

Diffusing Shades

The prismatic glass shade, which is made by the

Holophane Co., has the advantage of being pleasing in appearance, of concealing the filament if so desired and of giving a distribution of light in any desired manner. With the porcelain shade, by frosting the lower part of the lamp or by putting below the lamp a reflector which throws the light upward onto the shade the glare from the filament itself may be done

FIG. 5. HOLOPHANE REFLECTOR FOR EXTENSIVE DISTRIBUTION WITH MERIDIAN TUNGSTEN LAMP.

away with, but this does not give a diffusion of light and uniform distribution such as may be secured from the use of the prismatic shade or globe.

This prismatic globe, particularly for lights which must be hung low, is especially desirable as it conceals the filament entirely from the eye yet cuts off very little light. When used as a reflector the prismatic surfaces allow some light to pass through to the ceiling but throw the larger part of it downward.

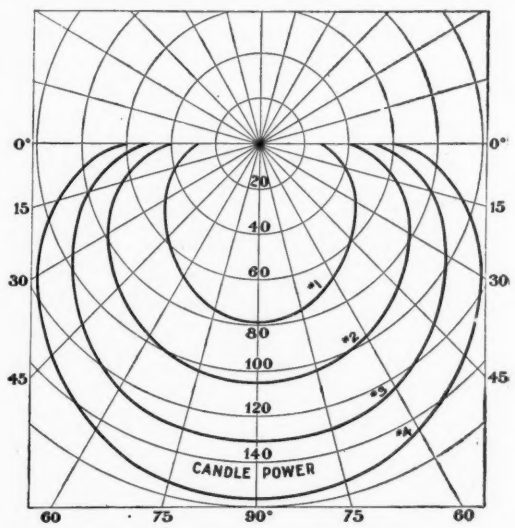


FIG. 6. LIGHT CURVES FROM NERNST SINGLE GLOWER LAMPS

The brighter a lamp the more important it is that the eye should be shaded from its direct rays and in the case of the tungsten lamp this becomes an absolutely necessary point in good lighting. Prismatic shades have, therefore, been devised to cover practically the entire body of the lamp where it is to be hung within the line of vision, 1 form being shown in Fig. 5. Sufficient distribution curves have been given to show that almost any distribution of light can be secured.

Special Lamps

Some of the special forms of lamps give particular curves of distribution. For instance, the Nernst gives

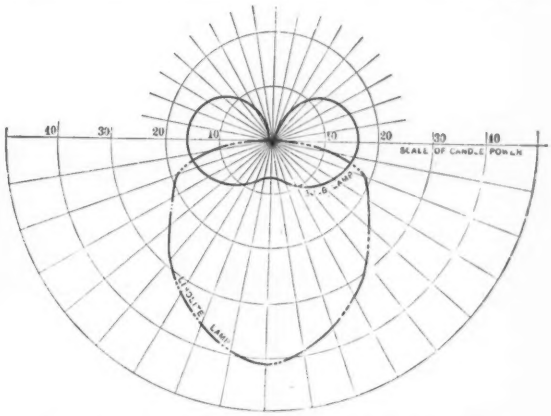


FIG. 7. LIGHT DISTRIBUTION FROM LINOLITE

distribution curves for single glower lamps, as shown in Fig. 6. No. 1 is for a 66-watt lamp with a 4-in. clear globe; No. 2 an 88-watt lamp under like conditions; No. 3 a 110-watt lamp with 5-in. clear globe, and No. 4 a 132-watt lamp with 6-in. globe.

Where light is wanted on a certain defined area,

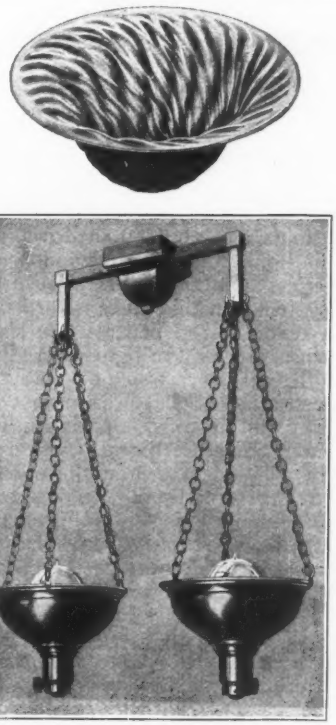


FIG. 8. REFLECTOR OF I-COMFORT SYSTEM, 2-LIGHT I-COMFORT FIXTURE

as in the case of art galleries, show window lighting and desks, the Linolite, referred to under the heading of Incandescent Lamps, is well adapted and gives distribution as shown in Fig. 7. The light is well con-

centrated within an angle of 100 deg. directly in front of the lamp and because of the lengthwise arrangement of the filament, light is used to good advantage.

Indirect Lighting

The ideal lighting for a room would be an evenly distributed but sufficient amount of light with no intense high spots and no deep shadows, such as is secured by the light from a north window on a pleasant day. An effect similar to this is secured by the "I Comfort" system. In this, light is thrown directly upward by a shade placed beneath the lamp and is reflected down again by the light-colored ceiling. The surface of the reflector, as shown in Fig. 8, is made corrugated so as to break up any cross reflection and shadows from the fixtures. Special fixtures are made for this system, or more recently reflectors have been brought out adapted to use on the old fixtures. The beautiful effect secured by the use of this system in the way of diffused lighting is seen in Fig. 2, p. 335, which is of a room 13 by 13 ft., using 1 60-watt tungsten lamp which would give the same cost for electric current as one of the ordinary 16-candlepower carbon filament lamps.

FIG. 9. GENERAL ELECTRIC DIFFUSERS FOR TUNGSTEN CLUSTERS

Fixtures

The use of the tungsten lamp has brought in many novelties in the line of fixtures, some of them designed to take the place of arc lamps in store and hall lighting, others designed to adapt the lamp for offices and home. Where single incandescents are used the smaller size of tungsten with one of the prismatic reflectors shown would be satisfactory. For mill lighting where arcs might otherwise be used, the tungsten clusters offer a satisfactory solution, a diffusing shade being made by the General Electric Co. to spread the light and give uniform illumination. A fixture and two forms of diffuser are shown in Fig. 9. The first of these is a 39-in. diffuser for mill lighting, taking either 5 or 6 lights, as may be desired. The second is an ornamental diffuser for use in halls and galleries where strong lighting is needed and ornamentation is desired. The third is for use in rooms with low or medium ceilings where the ceiling will act as a reflector and an ornamental fixture is required. Any of these diffusers may be made with 6 lights, 3 of 40 watts and 3 of 60 watts, arranged so that the 3 40-watt lamps may be used alone or the 3 60-watt lamps alone, or

FIG. 10. BENJAMIN WIRELESS CLUSTERS

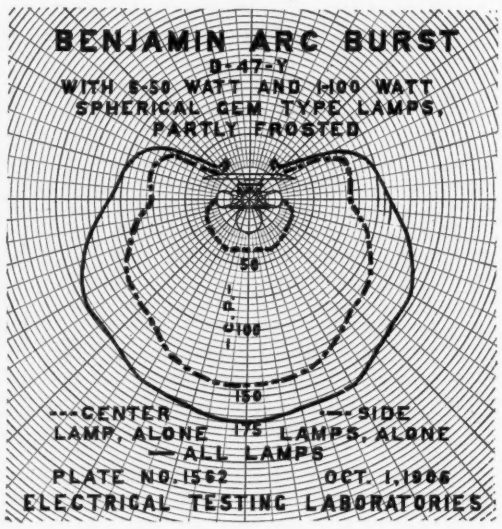


FIG. 11. DISTRIBUTION FROM 7-LAMP ARC-BURST

the entire 6 lamps, according to the lighting needs at different times.

One of the tests of an engineer's understanding of lighting requirements is the way in which he handles fixtures and cluster lighting. The simple form of cluster is a drop stem with 1 or 2 lamps carried on arms and a porcelain shade. This is usually not ornamental and is apt to be flimsy and may much better be replaced by a cluster ball in which the lamps are put directly onto a ball set on the end of a drop rod.

One of the neatest and most convenient devices for installation is the Benjamin wireless cluster system which is arranged with contacts in the sockets so that no wiring of sockets is necessary. Several examples of these clusters are given in Fig. 13. The first shows a 3-light cluster with porcelain shade, the second has 5 lights in a horizontal arrangement and 1 pointing straight downward with porcelain fluted shades, the third is a 5-light tungsten cluster called a tungsten arc, having a porcelain reflector which will be noticed is deep in the center so as to bring the filaments of the lamps in the right position with respect to the reflector. This cluster with 5 40-watt tungsten lamps gives a candlepower of 150 directly below the shade, with the greatest intensity at 60 deg. from the vertical; the fourth cluster is what is known as a pendant arc burst. It is intended to carry around the ring 6 50-watt Gem lamps and in the center a 100-watt Gem lamp. The distribution obtained with the center lamp alone, with the ring of lamps alone, and with all the lamps is shown in Fig. 14.

In using fixtures and shades it is well to keep in mind that the proper way to get good lighting is to plan the lighting installation and then fix up the plant, both as to wiring, panel boxes and generators, to fit the lighting. If the generating units are chosen first and the lights made to fit them, it is frequently the case that insufficient light will be provided or that a different kind of lamp will be provided from that which would best serve the lighting interests. In choosing shades it should be remembered that clear glass cuts off 10 per cent of the light, opaline glass 30 per cent, ground glass 30 per cent, prismatic globes 21 per cent, and heavy opal globes 35 per cent.

The style of distribution to be chosen depends upon the desired effect. For lights placed in the ceiling, lamps of high candlepower are needed with reflectors to throw the light downward, and if an enclosing bowl is used a reflector should be placed inside the bowl. For frieze lighting or where the lamps are studded in the ceiling, the sockets must be imbedded in the ceiling, and as this system is generally used only where the ceiling is low, the lamps are seldom shaded and should be frosted. It is an expensive form to install and is not efficient.

For reading or lighting of desks and machines the lights shold be hung vertically and equipped with concentrating reflectors. Where lights are used for ornamentation on pillars or wall brackets, they should always be frosted or shielded from the eye with prismatic globes or shades.

Frequently it is the case that to get satisfactory results a combination of systems must be used, part of the lights being for general illumination and part of them for specific places. In fact, where the lighting is planned for a working room of any sort it is usually easier on the eye as well as better economy to use a rather low intensity general lighting and put lamps over each place where work is to be done with shades adapted to throw the light just where it is wanted.

ARC LAMPS

IN ISOLATED plant lighting, the arc lamp is practically always used in the multiple form, as the series arc lamp is suitable only for large areas where it is hung high; as it has a high candlepower it takes large current. Such lamps must be set far apart in order to avoid an oversupply of light.

The 3 forms that are used are the direct-current multiple enclosed, the alternating-current multiple enclosed and the flaming or metallic arc. A form of the metallic arc, called the Magnetite, is made by the General Electric Co., the difference being largely in the details rather than in the principle. The variation in power and distribution of light is as shown in Fig. 1, taken from Questions and Answers about Electric Apparatus.

Formation of Arc

The arc in a lamp is really a stream of vapor coming from the electrodes. The stream of particles

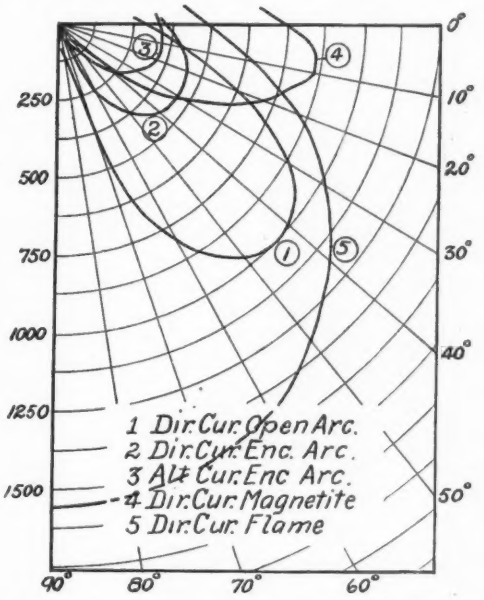


FIG. 1. DISTRIBUTION OF LIGHT FROM DIFFERENT TYPES OF ARC LAMPS

is carried from the negative electrode and in the open arc using carbons strikes against the end of the positive carbon, boring a crater into the end, which becomes so hot that it vaporizes the carbon particles and this vapor becomes luminous. In the carbon arc lamp this crater is the most intense light-giving point and a great part of the light is distributed from that crater, which accounts for the shape of the distribution curve.

The direct-current open arc which is run in series has this crater very deep, and the surface of the crater should reflect the light downward. The positive carbon can always be told by shutting off the current when the positive remains hot longer than the negative. In the enclosed form of arc the crater is less than in the open arc and since no air can get at the carbon the material is not burned rapidly, as it is in the case of the open arc.

Enclosed Arc, Direct Current

The direct-current enclosed arc made by the Westinghouse Electric & Mfg. Co. is of the differential type,

that is, has both shunt and series coils for controlling the length of the arc, the series coils acting to start the arc by lifting the upper carbon.

As the arc lengthens the current through the shunt coils increases, drawing up the end of the rocker arm to which they are attached and lowering the other end, which has a clutch that holds the carbon rod. At a certain point this clutch strikes a stop which opens it and allows the carbon to slip through by gravity, thus shortening the arc, when the series magnets lift their end of the rocker again, thus keeping the arc at the right length. Thus the series coils tend to lengthen the arc as the current strengthens and the shunt coils tend to shorten the arc as the main current weakens. A dashpot prevents too sudden movement

If by any possibility one lamp on a circuit goes out of commission it is short-circuited through a resistance. These lamps are made for connection 2 in series on a circuit of 220 volts or 5 in series on 550 volts.

When a lamp is used for multiple connection only, that is, a single lamp across 110 volt mains, the connections and operation are practically the same except that the shunt coil is omitted, also the short circuiting resistance. A steadying resistance must be put in series with the arc or there will be a considerable amount of flickering.

For Alternating Currents

Such lamps have a cored carbon, as the continuity of the arc depends on a continuous formation of carbon vapor and at every reversal of alternating current the current passes through zero value, at which time there is no heat generated by the current to vaporize the carbon. By using a soft core in one of the carbons the heat of the carbon tip itself is sufficient to keep up the arc for the brief instant while the current is passing through zero. If both carbons were cored it would give too long an arc and the carbons would wear out too fast.

In the alternating-current lamp, a reactance coil is used in series with the lamp to steady the arc instead of the resistance coil, and also springs are used on the armature of the regulating magnet to steady the armature, which otherwise is likely to chatter; the magnets have laminated cores.

The mechanism of the Wood alternating-current multiple arc lamp for a 110-volt system is shown in Fig. 2 and also the appearance of the lamp itself. A brass carbon tube is the foundation of this entire lamp, on the upper end being mounted 2 frames, between which is clamped a reactance coil. The upper frame of this coil is bolted to the under side of a lamp hood casting, which carries the binding post studs, a hanger link and the cut-out switch. The lower clamping plate of the coil is fastened firmly to the carbon tube and furnishes support for the magnet coils and operating mechanism.

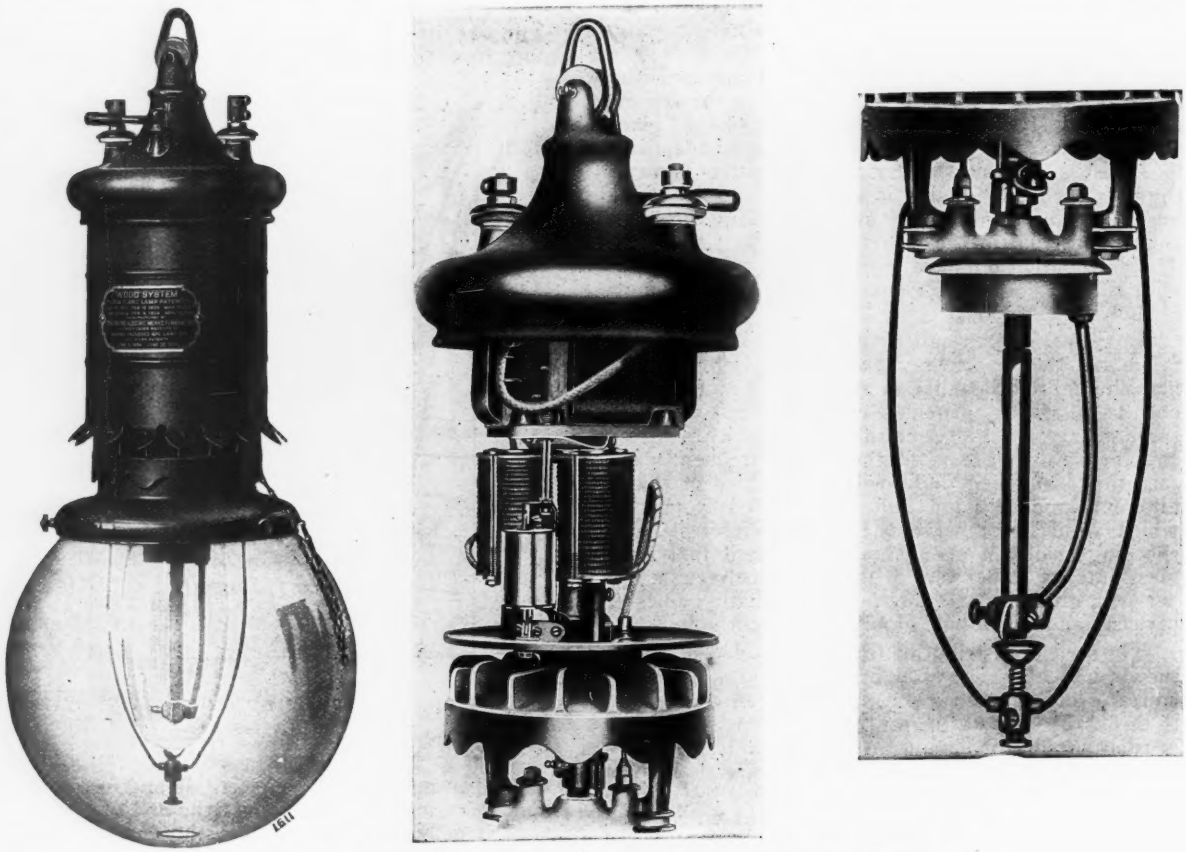


FIG. 2. "WOOD" ALTERNATING-CURRENT ARC LAMP AND DETAILS

At the lower end of the carbon tube a casting is mounted which radiates the heat thrown upward from the arc, preventing it from injuring the insulation of the coils, and also this casting serves as a mounting for the lower part of the lamp. The entire operating mechanism is enclosed in a top or hood.

The core on which the series magnet operates is U shaped, having the 2 coils close together. The core

is lifted by the magnet and draws upward the clutch, clutch rod and upper carbon; this strikes the arc and thus weakens the strength of the magnet. There is a slight working back and forth of the carbon at all times, the tendency being for the current to become weaker as the arc lengthens, which in turn tends to weaken the series magnet and allow the carbon to drop and shorten the arc. A dashpot is provided with plunger of graphite composition to prevent sudden jumping when picking up the carbon.

In all forms of enclosed arc lamp the arc proper is shut in by a glass globe which has connection with the outer air only sufficient to equalize the pressure. This is usually closed at the bottom and is held against an upper washer by a carrier so that it surrounds the lower carbon and the arc. Current is carried from the end of the series coil to the upper carbon by a spiral copper cable which lies in the tube,

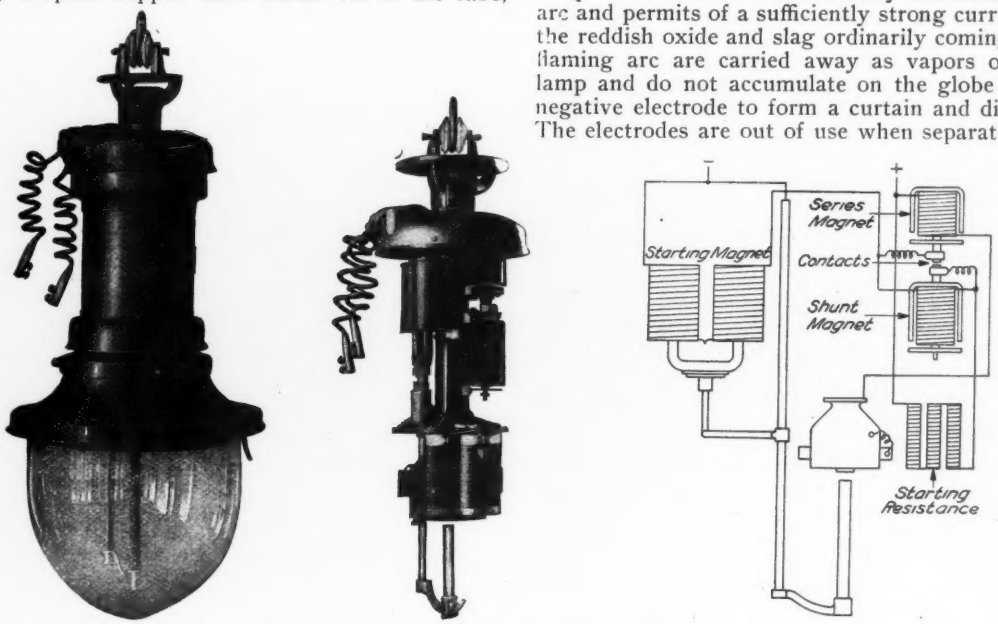


FIG. 3. GENERAL ELECTRIC MAGNETITE ARC LAMP

into which the carbon holder slides; so that no moving contact is depended on to carry current to the carbons.

The Magnetite Arc

The flaming arc lamp gives off its light from an arc produced by vaporizing some metallic compound, and the light comes from the arc proper rather than from the electrodes. In the magnetite lamp, which is made by the General Electric Co., the upper electrode is of copper while the lower one is a thin sheet-iron tube filled with a compound consisting mostly of magnetite, which is an iron ore. The copper block has a life of about 4,000 hr. while the lower electrode will burn from 150 to 175 hr. before needing renewal.

Connections of this arc are as indicated in Fig. 4. The main frame is a single large tube which acts as a chimney to carry away the gases from the arc and the entire regulating mechanism is carried at the sides of this tube. The operation differs from the carbon arcs in that the electrodes stand apart when the lamp is out of service and the position of the lower electrode is regulated instead of that of the upper electrode. When current is thrown on, the starting magnet lifts the lower electrode into contact with the upper one, which lets current flow through the series magnet, which in turn breaks the circuit through the starting magnet. This allows the lower electrode to fall and strike an arc and the lamp then burns with the carrier resting on its stop and the series magnet holding the cutout contact open. As the lower electrode is burned away, the voltage across the arc increases until, at a given limit, the shunt magnet lifts its armature and closes the cutout contact, putting the starting magnet into circuit; this lifts the lower electrode and re-establishes the arc at the proper length.

Westinghouse Flaming Arc

In the Westinghouse luminous flame lamp the position of the electrodes is reversed from that of the Magnetite. The negative carbon is carried at the top of the arc and is fed downward. In the center of the lamp is a tube which carries away the fumes from the arc and permits of a sufficiently strong current so that the reddish oxide and slag ordinarily coming from the flaming arc are carried away as vapors outside the lamp and do not accumulate on the globe or on the negative electrode to form a curtain and dim the arc. The electrodes are out of use when separated and the cutout contacts are closed. The upper cutout magnet is in series with the arc and the lower is shunted across the arc, while the starting and series magnets are in series with the starting resistance.

When current is turned on, the feeding magnets pull down their armature, bringing the electrodes in contact, which sends current through the series magnet, thus breaking the circuit through the feed magnets. The armature of the feeding magnets is pulled upward by a spring establishing the arc and as the arc lengthens the shunt cutoff magnet finally lifts the cutout contact until it establishes current through the feeding magnets which drop the upper carbon to give the arc its proper length.

Energy Used in Arcs

As comparison of performance and energy used in the different kinds of arc lamps, the mean of tests on 8 direct-current arc lamps gave 4.9 amperes of current at 110 volts across the lamp terminals, showing 529 watts used up in the entire lamp, 384 of which were in the arc and 144 in the operating mechanism, 1 watt being lost in connections. In testing arc lamps the candlepower measured is the average of that given below a horizontal plane and in this case was 272

candlepower with a clear globe, giving 1.98 watts per candlepower in the lower hemisphere.

For alternating-current arc lamps the mean of tests on 7 lamps gave 6.29 amperes; watts in the lamp, 417, with a power factor of 0.6; watts in the arc, 342, with a power factor of 0.76; watts used in the mechanism, 74.5; the mean spherical candlepower, lower hemisphere, 190; the watts per candlepower, 2.23.

In the old-style, direct-current, open arc, which was nominally called 2,000 candlepower, the current used was 9.5 to 10 amperes, the energy consumed 450 to 480 watts and the real candlepower about 1,200, while the lamp rated at 1,200 candlepower or the "half-arc" used 6 to 7.5 amperes, took 325 to 350 watts energy and gave actually about 700 candlepower. These arcs have an energy consumption of 0.6 to 1.25 watts per candlepower, but their regulation is poor, the generators used are inefficient and their use is fast dying out.

For flaming arcs the current is 10 amperes; 46 volts are used across the arc, the average candlepower in the lower hemisphere is 3,029 and the watts per candlepower 0.153; while a smaller size takes 3.05 amperes at 42.7 volts across the arc, an energy consumption of 130 watts, an average candlepower in the lower hemisphere 908, and energy 0.143 watts per candlepower. In the magnetite arc, current used is 4 amperes, volts across the arc 80, the energy used 320 watts, the candlepower for the lower hemisphere 368, the watts per candlepower 0.87. With enclosed carbon lamps the voltage across the arc is 70 to 80 and must be regulated within moderate limits to avoid irregular effects in the lamp action. Three effects are caused by wrong arc adjustment: hissing, jumping and flaming. The hissing comes from an arc that is too short, the jumping from an arc that is somewhat too long, and the flaming from an arc that is excessive in length. Poor carbons will cause the points of jumping and flaming to come almost together. The life of the electrodes and the frequency of trimming of arcs are about as follows: For the enclosed arc, either direct or alternating, 150 hours. For the magnetite the same time and for the flaming arc 15 hours.

In choosing the glassware for arc lamps it should be remembered that if the lamp is hung so low that the arc comes in the line of vision it is extremely trying to the eyes, and the arc must, therefore, be heavily shaded, but this cuts off a considerable part of the light, and this is one reason why for interior work the arc lamp is not more generally used. Clear glass will cut off 10 per cent of the light, a light ground glass 30 per cent, heavy ground glass 45 to 50 per cent, and a strong opal 50 to 60 per cent.

A TALK WITH A CHIEF ENGINEER
PRACTICAL POINTERS ON SCREW CUTTING

By Wm. Kavanagh

THE interesting and useful information which the chief gave in his last talk impelled the writer and Kingsly to interview the chief on the practical subject mentioned above. On entering the chief's engineroom we found him busy giving instructions to one of his assistants about how to grind a thread-cutting tool for a lathe, and, in answer to questions, the chief explained that the machinist used a gage in grinding the tool, as shown in Fig. 1, and that when the tool is properly ground no light will appear between the cutting edge of the tool and gage; besides the tool must have what we call clearance, as shown by the full line in Fig. 2. Should the tool be ground as shown by the dotted line, the tool would bind in the thread groove and prevent any further increase in the depth of the thread.

"In cutting threads there are some things to be noticed carefully. First, the tool must be properly ground and sharp; second, the correct gears must be on the lathe; and, third, the cutting tool must be perpendicular to the center line of the lathe, as shown in Fig. 3."

Here Kingsly wanted to know how to find the gears to cut a given number of threads to the inch.

"In considering what gears are necessary," the chief continued, "every lathe made nowadays has attached an index plate which will give the numbers of gears to place on the lathe spindle and lead screw to cut a given number of threads to the inch. Of course, if this index plate were lost, we could still find the gears by multiplying the number of threads to the inch on the lead screw and the

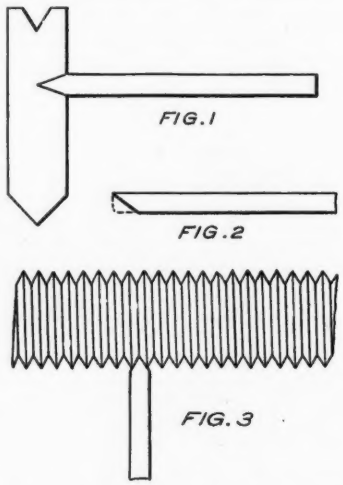


FIG. 1. GAGE FOR GRINDING TOOL
FIG. 2. THREAD CUTTING TOOL SHOWING CLEARANCE
FIG. 3. METHOD OF CUTTING THREADS

number of threads to be cut per inch by some small number, and then consider whether the lead screw or lathe spindle must revolve the faster. If the lead screw contained 8 threads per inch, and we were going to cut, say 16 threads to the inch, then we must put on the lead screw the gear containing the greatest number of teeth.

"If you will make a comparison between the number of threads to be cut and the number of threads on the lead screw in the case I have given, you will find the ratio will be as to 2 to 1, that is, the live spindle must revolve twice as fast as the lead screw; so you see, Kingsly, any small number that will give a gear on the lathe and hold this ratio will be correct.

"For the sake of illustration I will use 3 as a multiplier, thus: $3 \times 8 = 24$ and $3 \times 16 = 48$; here we see 48 is to 24 as 2 is to 1, and 24 will go on the spindle for the reason I have given you. Of course, the gear containing 48 teeth will go on the screw. You will notice I could have used either 2 or 4 as a multiplier and maintained the same ratio.

"In cutting threads it is important to have some guide so as to try or test the new screw, as by so doing we are enabled to obtain a tight- or loose-fitting thread." At this point in the chief's discourse the telephone rang up for him and, after thanking him for his kindness and promising to call at some future time, we departed for our respective enginerooms.

WIRING PLANS

THIS naturally divides itself into 2 parts: the planning of the circuits and the installation proper. Before any planning can be done the place where lights are to be installed must be decided upon, the kind of lights and the size units for each position and preferably an estimate made of the time during which each unit will burn, because this materially affects the placing of switches and panel boards. For the sake of economy the lines of wire should be run as directly as possible and the location of switches kept near to the lights or fixtures which they control.

The wires which take the current directly to the lights or fixtures, the "taps," are put in on the 2-wire basis and ordinarily taken direct from the mains, which may be either 2-wire or 3-wire, as economy dictates. In the 2-wire system of distribution all lamps and apparatus are bridged across 2 wires which are carried out from the terminals of a single dynamo or from the bus bars of the switchboard. This means that all lamps will burn at the voltage given by the generator less whatever drop there is in the transmission circuit and if 110 volts is used at the lamp, as is most common practice, this means that a large wire must be used in the mains with consequent heavy investment in copper and also that as a large current is necessary to supply the lamps, the energy lost in transmitting current through the mains will be large.

Three-Wire System

By connecting 2 dynamos in series and running a wire out from the junction of the 2 dynamo terminals it is possible to connect 110-volt lamps from the outside wire on each side to this common or neutral wire, so that current may be sent out on one outside wire, passed through the lamps, through a short section of the neutral wire, through other lamps, back to the second outside wire, and to the generators, thus giving practically transmission at 220 volts, while the voltage on the lamps is only 110. This results in a saving in copper, since the neutral wire can be only a fraction as large as the outside wires, and at the same time a saving in the amount of energy lost in transmission.

In cases where alternating current is used for both lighting and power, generally either the 2-phase or the 3-phase system should be adopted, because of its greater utility on the power circuits. In such a case the lighting is usually connected as a 2-wire system and distributed as evenly as possible among the different phases.

In order to secure the best results evidently all lamps should burn at exactly the same voltage. This is not possible, since there is a certain drop of voltage in transmission lines and those lamps nearest to the dynamo will get slightly higher voltage than those far away. To overcome this as much as possible the loop system is sometimes adopted and sometimes the tapered or conical system of mains is used. This method of tapering the mains does not, however, secure even voltage along the lines, but does secure uniformity in the drop in voltage within the line. It will still be true that the lamps near the dynamo are getting a higher voltage than those at the far end of the line.

It is usually sufficient for all practical purposes to use the same size wire the entire length of a circuit, the size being, of course, proportioned to the load that the circuit has to carry and the length of the circuit.

Feeders

Frequently where the distances are long and the lamps are strung out over a considerable distance, the center of the lamp load is figured out and feeders run from the switchboard directly to this lamp center, these feeders being simply to carry current to the distributing mains. In cases where part of the lighting load is near the dynamos and part of it is at a considerable distance away, all being fed from the same bus bars, a booster may be used, which is simply a dynamo driven by a motor, the motor taking its current from the bus bars of the switchboard and the dynamo taking the current which goes to the long feeder and raising its voltage so much as may be necessary to take care of the drop in voltage due to the feeders. Where the feeders are all of some considerable length, the dynamo may be fitted with a compound winding, such that the voltage of the machine will rise as the load is increased or, as it is called, overcompounded.

Laying Out Circuits

After spotting out the lighting system on a plan of the building or works, those lights which are near together and which are to burn about the same amount of time can be joined up into circuits and the switches placed at convenient positions for controlling the circuits. Then it becomes necessary to decide on the size of wire needed for the distributing mains, for the taps and for the feeders. The condition which controls is usually the amount of drop or loss in voltage which is permissible in the wiring. For long transmission 10 per cent of the generator voltage is allowed, but for short transmission 2 per cent is as much as should be permitted, with 1 volt loss in the distributing mains and taps.

In calculating the wiring, it is necessary to work backwards from the lamps to the switchboard. The taps which carry current directly to the fixtures are usually of No. 14 wire because this is the smallest size allowed by the underwriters in order to give the required mechanical strength. Having decided where the panel box or connection of the distributing main to the feeders is to be located, the distance from that point to the "center of gravity of the lamp load" on the mains must be determined.

This center of gravity is the point at which all the lamps on the circuit might be concentrated and still give practically the same transmission distance that they do when spread about. It is found by taking some point outside the group of lamps, measuring the distance from that point to each of the fixtures and multiplying the number of feet by the number of lamps for each fixture. Dividing this by the total number of lamps gives the distance from the point first chosen to the center of gravity of the lamps, and its direction can easily be determined by inspection. The nearest point to this on the distributing mains will be the center of gravity of the lamp load. The distance from the center of gravity to the panel or distributing box is to be measured and the total current found for the lamps on this distributing main.

Figuring the Wire

A drop of 1 volt is allowed from the panel box to this center of gravity under ordinary conditions. The resistance of a piece of copper wire 1 ft. long and 1 mil, or 0.001 in. in diameter, is 10.8 ohms at 75 deg.

TABLE III. WIRE SIZES FOR CIRCUITS.

Volts at Generator.				Actual Volts Lost.	Ampere – Feet = Amperes in Circuit × Single Distance.																										
2,200	1,100	550	250	125																											
Percentage Loss.																															
0.045	0.09	0.18	0.4	0.8	1	198	315	500	796	1,265	1,595	2,010	2,535	3,198	4,030	5,080	6,417	8,150	10,100	14,910	19,850	24,820	30,000	34,780	39,750	44,750	49,700				
0.09	0.18	0.36	0.8	1.6	2	396	630	1,000	1,597	2,530	3,190	4,020	5,070	6,395	8,060	10,165	12,835	16,300	20,200	29,820	39,700	49,640	60,000	69,560	79,500	89,500	99,400				
0.135	0.27	0.54	1.2	2.4	3	594	945	1,500	2,388	3,795	4,785	6,030	7,605	9,593	12,090	15,245	19,252	24,450	30,300	44,730	59,550	74,460	90,000	104,340	119,250	134,250	149,100				
0.18	0.36	0.72	1.6	3.2	4	792	1,260	2,000	3,184	5,060	6,380	8,040	10,140	12,790	16,120	20,330	25,670	32,600	40,400	59,640	79,400	99,290	120,000	139,120	159,000	179,000	198,800				
0.225	0.45	0.90	2.	4.	5	990	1,575	2,500	3,980	6,325	7,975	10,050	12,675	15,988	20,150	25,410	32,087	40,750	50,500	74,550	99,250	124,100	150,000	173,900	198,750	223,750	248,500				
0.27	0.54	1.08	2.4	4.8	6	1,188	1,890	3,000	4,776	7,590	9,570	12,060	15,210	19,186	24,180	30,490	38,504	48,900	60,600	89,460	119,100	148,920	180,000	208,680	238,500	268,500	298,200				
0.36	0.72	1.44	3.2	6.4	8	1,584	2,520	4,000	6,368	10,120	12,700	16,080	20,280	25,580	32,240	40,660	51,340	65,200	80,800	119,280	158,800	198,560	240,000	278,240	318,000	358,000	397,600				
0.45	0.9	1.8	4.	8.	10	1,980	3,150	5,000	7,960	12,650	15,950	20,100	25,350	31,990	40,300	50,800	64,170	81,500	101,000	149,100	198,500	248,200	300,000	347,800	397,500	447,500	497,000				
0.52	1.14	2.27	5.	10.	12.5	2,478	3,940	6,250	9,950	15,820	19,930	25,150	31,680	39,990	50,350	63,500	80,200	101,800	126,300	186,500	248,000	310,500	375,000	435,000	496,500	559,000	611,100				
0.675	1.35	2.7	6.	.....	15	2,970	4,725	7,500	11,940	18,975	23,925	30,150	38,025	47,968	60,450	76,210	96,257	122,500	151,500	223,650	297,750	372,300	450,000	521,700	596,250	671,250	745,500				
0.90	1.8	3.6	8.	.....	20	3,960	6,300	10,000	15,920	25,300	31,900	40,200	50,700	63,950	80,600	101,650	128,350	163,000	202,000	298,200	397,000	496,400	600,000	695,600	795,000	895,000	994,000				
1.13	2.27	4.55	10.	.....	25	4,956	7,880	13,500	19,900	31,640	39,860	50,300	63,360	79,980	100,700	127,000	160,400	203,600	252,600	373,000	496,000	621,000	750,000	870,000	993,0001	118,0001	222,200				
1.35	2.7	5.4	12.	.....	30	5,940	9,450	15,000	23,880	37,950	47,850	60,300	76,050	95,930	120,900	152,450	192,520	244,500	303,000	447,300	595,500	744,600	900,000	1,043,400	1,192,500	1,342,500	1,491,000				
1.8	3.6	7.2	.....	.....	40	7,920	12,600	20,000	31,840	50,600	63,800	80,400	101,400	127,900	161,200	203,300	256,700	326,000	404,000	596,400	794,000	992,800	1,200,000	1,391,200	1,590,000	1,790,000	1,988,000				
2.25	4.5	9.1	.....	.....	50	9,900	15,750	25,000	39,800	63,250	79,500	100,500	126,750	159,880	201,500	254,100	320,870	407,500	505,000	745,500	992,500	1,241,000	1,500,000	1,739,0001	1,987,5002	237,5002	2,485,000				
4.55	9.1	18.	.....	.....	100	19,800	31,500	50,000	79,600	126,500	159,500	201,000	253,500	319,800	403,000	508,000	641,700	815,000	1,010,000	1,491,000	1,985,000	2,482,000	3,000,000	3,478,0008	3,975,0004	475,0004	970,000				
9.1	18.2	.....	.....	.....	200	39,600	63,000	100,000	159,200	253,000	319,000	402,000	507,000	639,500	806,000	1,016,500	1,283,500	1,630,000	2,020,000	2,982,000	3,970,000	4,964,000	6,000,000	6,956,0007	7,950,0008	950,0009	1,940,000				
Size Wire B. & S. gage for Direct Current.						14	12	10	8	6	5	4	3	2	1	0	00	000	0000	300,000	400,000	Circular Mils. 500,000	600,000	700,000	800,000	900,000	1,000,000				

F. The resistance varies directly as the length of the wire and inversely as the square of the diameter. For convenience in figuring, the area is reckoned in circular mils, a circular mil being the area of a wire 0.001 in. in diameter. In this way the area in circular mils is equal to the square of the diameter expressed in thousandths of an inch and the wire table is made out with the area on this basis instead of in square inches.

As the resistance of a wire 1 ft. long and 1 mil in diameter is 10.8 ohms, that of a wire 2 ft. long would be 21.6 ohms and of a wire 10 ft. long would be 108 ohms, all of these wires being 1 mil in diameter. If, on the other hand, the wire was 1 ft. long and 2 mils in diameter, the resistance would be $10.8 \div 4$, or 2.7 ohms, while if it were 5 mils in diameter the resistance would be $10.8 \div 25$, or 0.43 ohms. In other words, to find the resistance of a wire, multiply 10.8 by the length of the wire in feet and divide by the circular mils cross section.

The wiring must conform to 2 requirements, first it must carry the current with not more than the allowed drop, second it must have safe carrying capacity according to the Underwriters' Rules for the current to be handled. Its carrying capacity is given in Table IV, Properties of Wire, for each size wire commercially used in transmission circuits.

The fundamental principle in calculation of electric circuits is that the drop in the circuit is equal to the current carried times the resistance of the circuit. We have seen that the resistance of the wire is equal to 10.8 times the length divided by the square of the diameter; hence the drop in a circuit is equal to the current times the length times 10.8 divided by the square of the diameter, the length in this case being the total wire in the circuit from the panel board to the center of gravity of the lamps, or twice the distance from the panel board to the lamp center of gravity.

Turning this around, it means that the square of the diameter in mils or the circular mils of the wire will equal the current times the distance from panel board to center of gravity times 21.6 divided by the drop allowed. This expression is one which can be used for any circuit, either the distributing mains, the feeders or the taps, using always the distance through which current is transmitted, the current in the circuit and the drop allowed in that circuit. As there are a number of constants in this expression it is easy to work out Table III, which greatly facilitates making of computations.

Use of Wiring Table

To show the use of this, suppose that a current of 20 amperes is to be transmitted a distance of 300 ft. Multiply current by the distance, giving us 6,000 ampere-feet. If the drop allowed is in this case 1 volt, we start in the column headed Actual Volts Lost, on the line 1, and trace to the right until we find the number nearest to 6,000. At the bottom of this column will be found the number of wire on the Brown & Sharpe gage which should be used for the circuit No. 00.

This same method of computation can be used for the distributing mains in alternating-current systems where the distances are not great and the wires are close together, as in conduit wiring or ordinary house wiring at low voltage, the only difference being that in getting the ampere-feet for a single-phase alternating current the product of current times transmission distance should be divided by 0.9 if the load is all lights and by 0.82 if the load is partly lights and partly power; and for alternating-current circuits 2-phase with 4 wires or 3-phase with 3 wires, the ampere-feet

should be divided by 0.45 if for lighting alone, or by 0.41 if for lighting and power before using the table. For instance, if in the above example 20 amperes is to be transmitted single phase and is for both lighting and power purposes, $20 \times 300 \div 0.82$ gives 7,300, and on the 1-volt line in the table we find the nearest figure to this number and at the bottom of the column the size wire required, No. 000.

To give the best life efficiency of lamps the system should be laid out carefully to keep the drop in voltage the same from the generators to all points on the system, as variation in the voltage on lamps is a cause of short life, if the voltage is too high and of poor lighting, if the voltage is too low.

Having worked out the size of wire required in each set of distributing mains, the center of loads on the feeders should be determined and the size wire needed to go from the switchboard to panel box, calculated by the same method. This will be made clearer by the carrying through of the computations in a specific case. The wiring for a small mill building will be figured out in detail in the July issue.

When arranging a 3-wire system, the lamps in the whole plant must be divided as nearly as possible on the 2 sides so that they will balance both in number of lamps and in the time at which they will be used. The size of the neutral wire will depend upon the care with which this balancing of load is done. In some cases where it is thought necessary to use the system for 2-wire distribution at certain times, the neutral wire would have a section as large as that of the 2 outer wires, but this would evidently be a waste of material and is not ordinarily done. Ordinarily, if the neutral wire is made to carry 25 per cent of the load on either outside wire, it will be sufficient. The outside wires are calculated in exactly the same way as if the neutral wire were not present. When providing for switches, terminal contacts, etc., the following figures will be a safe guide, the values being in amperes per square inch. For switch blades, copper on copper, 60 to 80: for brass on brass, 40 to 50; for a screwed contact copper to copper, 150 to 200; for a clamped contact 100 to 125. And for cross section in bus bars and switchboard connections, copper wire 1,200 to 2,000 amperes; wire cable 1,000 to 1,600 amperes; copper rod 800 to 1,200 amperes, and composition casting 500 to 700 amperes per square inch.

TABLE IV. PROPERTIES OF COPPER WIRE.

Gage No.	Diam. Mils.	Area Cir. Mils. B. & S.	Bare Wire.				Underwriters.		Safe Ampere. Carrying Capacity.		Size Conduit Needed.		
			Lbs. per 1000 ft.	Ohms per 1000 ft.	Ft. per lb.	Ft. per ohm.	Lbs. per 1000 ft.	Ft. per lb.	Open or Weatherp'f	Concealed or Rubber.	1 Wire.	2 Wires.	3 Wires.
20	32	1,021	3.09	10.158	323.32	98.44							
18	40	1,624	4.92	6.388	203.31	156.54	11.	90.	5	3	½	½	½
16	51	2,583	7.82	4.018	127.87	248.90	14.	70.	8	6	½	½	½
14	64	4,106	12.44	2.527	80.42	395.79	22.	45.	16	12	½	½	½
12	81	6,530	19.77	1.589	50.58	629.32	31.	32.	23	17	½	½	¾
10	102	10,380	31.44	0.9995	31.81	1000.5	50.	20.	32	25	½	½	1
8	128	16,510	49.99	0.6285	20.00	1591.1	69.	14.5	46	33	½	1	1
6	162	26,250	79.49	0.3953	12.58	2529.9	105	9.5	65	45	¾	1	1¼
5	182	33,100	100.23	0.3135	9.98	3190.2	125	8.0	77	53	¾	1¼	1¼
4	204	41,740	126.40	0.2486	7.91	4022.9	144	6.9	92	63	¾	1¼	1¼
3	229	52,630	159.38	0.1971	6.28	5072.5	200	5.	110	75	¾	1¼	1½
2	258	66,370	200.98	0.1563	4.98	6396.7	250	4.	131	88	¾	1½	2
1	289	83,690	253.43	0.1240	3.95	8066.0	313	3.20	156	105	1	1½	2
0	325	105,600	319.74	0.0983	3.13	10176.4	363	2.75	185	125	1	2	2
00	365	133,100	402.97	0.0780	2.48	12825.4	500	2.00	220	150	1	2	2
000	410	167,800	508.12	0.0618	1.97	06172.1	666	1.50	262	181	1¼	2	2½
0000	460	211,600	640.73	0.0490	1.56	20392.9	800	1.25	312	218	1¼	2	2½
	630	300,000	932	0.03355					405	273	1½	2½	3
Cables.	727.3	400,000	1242	0.02516					503	332	1½	3	3
	814.5	500,000	1553	0.02013					595	390	2	3	3½
	891.9	600,000	1863	0.01666					682	440	2	3½	4
	963.9	700,000	2174	0.01438					765	488	2	3½	4
	1030.5	800,000	2474	0.01258					846	540	2	3½	4
	1092.6	900,000	2795	0.01118					924	585	2½	4	4½
	1152.	1,000,000	3106	0.01006					1000	630	2½	4	4½

INSTALLATION OF WIRING

THREE general methods of wiring are in common use, open wiring, wiring in molding, and conduit or pipe work. The open method is suitable only for wiring which is installed in private houses or small buildings, before the lath and plaster are put on, or for mill construction where the wires can be run on beams in plain sight, and where there is no moisture. Molding is used where wire has to be installed in buildings already completed, and for the cheaper class of work where wire has to be run on walls of any fireproof building, which has tile partitions. For all concealed work, rubber covered wire is necessary, while for out-door use, the weatherproof wire is used, having at least 3 coats of braiding, impregnated with a dense moisture-proof material.

Open Wiring

For open wiring, the wires are carried on porcelain knobs or cleats, the knob being the better construction and this should preferably be of the 2-piece type, in which the wire is carried between the upper and lower portions rather than being tied to the knob, with a tie wire. The wires are either run along separate beams, or where run between floor and ceiling, are carried through the beams, the holes being bored at an angle, and wire run through in a zig-zag course. Porcelain tubes are used where the wire passes through beams, and also where wires cross each other. For a 3-in. insulator, it takes 8 in. of wire to make a tie on a No. 14 wire, and for larger wires, the correspondingly longer tie wire is needed. In all cases the insulation of the tie wire should be equal to that on the line wire. For voltages up to 300 the wires must

be at least 2.5 in. apart and the standard porcelain cleats may be used where the walls are dry. Wires must be supported at least every 4.5 ft., and when exposed to injury must have the supports nearer together.

Where carried through floors, the wires should pass through either porcelain tubes or iron tubing. Where carried in porcelain tubes a box should protect the tubes, and when carried through iron tubing flexible conduit is put around the wires where they pass through the iron. The iron tube or the box should extend at least 6 in. above the floor, and the iron 6 in. below.

All wires of a single circuit should pass through 1 pipe, as, if they are carried through 2 separate pipes

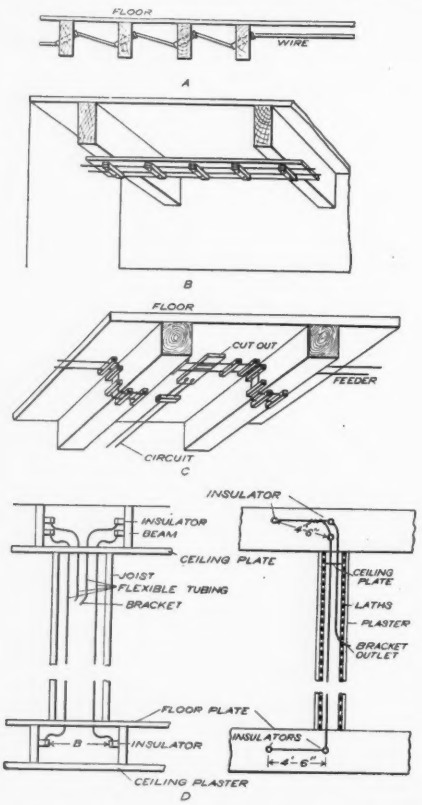


FIG. 1. RUNNING WIRES ON BEAMS FOR OPEN WORK. A, TUBES THROUGH BEAMS; B, CLEAT WORK ACROSS BEAMS; C, GOING AROUND BEAMS; D, IN PARTITIONS AND CEILINGS FOR FISHED IN WORK.

and are used for alternating current, the induction effect is large. Wherever there is any danger of dampness or acid fumes, the wires should be run on knobs, never on cleats, and must be rubber covered. If the building is perfectly dry, weatherproof wire, which is considerably cheaper, may be used. Where there is dampness, the feed wire on the vertical wall must be boxed in or put in iron conduits. Where the walls are dry, moldings can be used, or can be used to the height of 6 ft. from the floor, and above that the wire may be exposed on cleats or knobs.

In any place where the wire passes out-doors, waterproof devices and rubber covered wire must be used, and where wire is run out of a building, it is well to install a switch or fuse cutout, and iron tubes must be used, bent to form a drip loop, or porcelain tubes set at an angle sloping outward, so that all water will be carried away from the wiring inside the building. Wherever wires cross a metal pipe, they should run over, not under the pipe, and should be protected with porcelain tubes, so that no harm will result if they drop upon the pipe. Wherever porcelain tubes are used for cross overs on pipes or crossing wires, they should be securely taped to the wire so that they cannot slip out of place.

In damp places, lamp cord should never be used. If it is necessary to use a pendant light, use 2 separate rubber covered wires.

No size of wire smaller than No. 14 should ever be used on account of mechanical strength needed and for mains to which connections are to be made, a

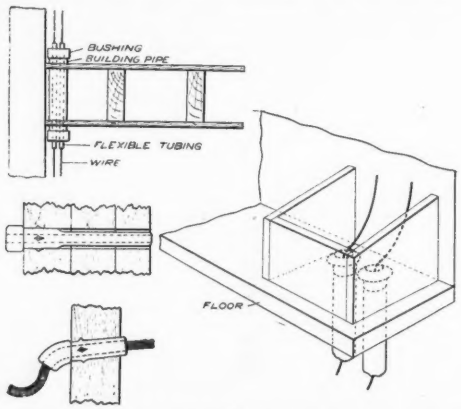


FIG. 2. PASSING THROUGH FLOORS AND WALLS AND ENTERING WITH A DRIP LOOP

wire smaller than No. 10 is not advisable, because the mechanical work of making connections is likely to weaken the wire to a certain extent.

Splicing

Splicing of wires or joining a branch to a main wire should always be made by twisting the wires together or twisting one wire around the other, so that the joint will be mechanically strong enough to carry all strain which may come upon it, without any soldering. The joint should then be carefully tinned and soldered in order to give perfect electrical contact and avoid any corrosion. Where wires are too large to be twisted together, the ends are given a short bend and the 2 wires wrapped firmly together with a smaller bare copper wire, after which the joint is thoroughly tinned and soldered, preferably by pouring hot solder over the joint. The joint is then insulated by wrapping with 2 thicknesses of pure rubber tape and then layers of friction tape, sufficient to make the insulation thickness equal to that of the wire, after which the whole joint should be painted with waterproof paint.

Molding Work

In all cases where molding is used, it must be placed against a dry backing. If the wall is of brick or plaster, and liable to dampness a backing board must be put on before the molding is used. Also the molding must have a suitable capping. In damp places, or where subject to fumes, such as stables, or breweries, the molding must be of metal. Wooden molding should be used only where it can be inspected at all times, never in shafts of any kind.

In putting up molding on a ceiling, a much better

looking job is secured, if the molding is always carried through to the side of the room, even if part of the molding is not used. Where molding runs must be carried through floors, it is often cheaper to run conduit wiring in a shaft than to carry the molding to the floors, and change to pipes through the floors. For changing from conduit to molding circuits, a convenient "condulet" fitting is manufactured by the Crouse-Hinds Co. of Syracuse.

Careful miter joints should be made in the molding, where an angle is turned and a careful tee joint where there is occasion to take a branch circuit from a main. In nearly all molding jobs, a certain part of the work, will be run as concealed that is inside the partitions, the wires being fished from the molding to the outlet. In this case, that part of the wire which is fished in, must be covered with flexible tubing, such as "circular loom" or "flexduct," and single-braided rubber wire may be used for the fished-in portion.

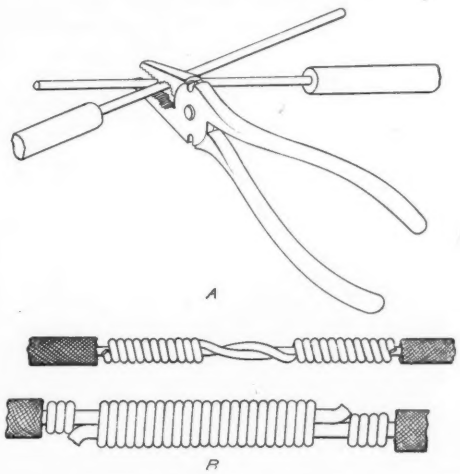


FIG. 3. A, MAKING A WIRE SPLICE, AND THE TWIST COMPLETED. B, A WRAPPED JOINT ON LARGE WIRE

Molding should always be run in as inconspicuous position as possible, and if it is necessary to run it on the open ceiling it should be arranged so as to form regular panels. Often it can be run so as to take the place of a picture molding or at a part of the baseboard so that it becomes merely a part of the wooden trim of the building and in certain cases should be made of material to match the rest of the trim.

If porcelain tubes are used to carry molding work through a floor, a protecting box must be put around the tubes to prevent breakage.

For drop lights on circuits run from moldings, rosettes are used and these should be of such form that the main wire need not be cut in making connections. The rosettes are mounted directly on the molding and the cover of a rosette should be so made that it will carry a knob of cord to take the weight.

Where a branch line is to be connected, a branch box may be used, made out of porcelain and with porcelain cover to match on to the capping, or the branch wire may be carried directly into the branch molding, the tap from the far wire in the main molding being carried outside the capping of the main molding.

In carrying wires through wooden moldings, approved rubber covered wire should always be used, to avoid any danger from the molding becoming damp. The lip between conductors should be ½ in. thick, and the backing should be solid, not less than ⅜ in. thick under the grooves, and not less than ¼ in. thick on each side of the groove. Care should be taken in driving nails into the molding, not to puncture the insulation of the wire and this should be especially looked after when putting on capping.

Where metal molding is used, it should be of iron or steel with back at least 0.05 in. thick and the cap not less than 0.04 in. thick, so arranged that the grooves or wireway will be entirely closed when the capping is in place and the entire molding should be thoroughly galvanized, or coated with a rust preventive. When the backing is held in place by screws or bolts from the inside, depressions must be provided so that the heads of the screws will be flush with the surface of the molding.

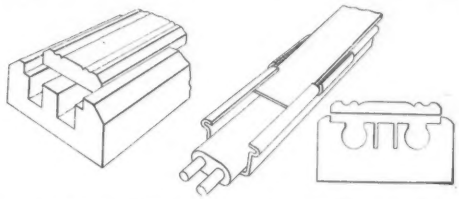


FIG. 4. A, WOOD MOLDING AND CAPPING. C, WIRE GRIP MOLDING. B, LUTZ METAL MOLDING.

Molding is not allowable where the voltage between 2 wires in the same molding is over 300 volts or for circuits which carry more than 660 watts, and if alternating current is to be used, the 2 or more wires of a circuit should be run in the same metal molding:

Where wire from either exposed work or from molding comes into an outlet or fixture for making a connection, each wire should be incased separately in a continuous length of flexible tubing which extends from the last knob or cleat or from the end of the molding, to the connection in the fixture.

FIG. 5. CONDULET CONNECTION FITTINGS

Conduit Wiring

This may be done with either flexible or rigid conduit. Of the flexible conduits, two fibrous styles are used; the circular loom, and the flexduct, and a third form sometimes used is known as Greenfield, consisting of a spiral wound metal tube which can be bent to any curve. A variation of this Greenfield conduit is the BX steel armored cable which consists of 2 wires made up into a cable with the steel armor already wound on. The flexible type of conduit and the steel armored cable are used particularly for running from moldings to outlets in a molding job, or for fished in work where a house has already been built and it is desired to install electric wiring.

In the fishing of conduits, steel tape or wire is used, the ends being turned over and made into a loop or hook; the wire or tape is run from one opening to another and a stout cord drawn through by which the conduit is pulled in. In such cases, conduit should be without joint from one opening to another, whether it be the flexible conduit or the steel armored.

For vertical runs, a chain is employed, dropping it from above until it strikes the floor below, when a hole can be made and the end of the flexible conduit attached.

In flexible metallic conduit, double-braided rubber-covered wire must be used, and no conduit smaller than ½ in. internal diameter is allowed by the Underwriters. In the fibre conduit, single-braided rubber-covered wire may be used, but no diameter less than ⅜ in. inside is allowed. When coming to switch-boxes or junction boxes, the flexible conduit is drawn into the box, and the end made fast. Auerbacher states that BX cable is cheaper to install than fibre tubing and makes a much more satisfactory job. Where this is used, the steel armor must be grounded and if the cable is run in damp places, there should be a lead sheath between the conductor and the steel armor; this form of cable is known as BXL.

Iron Conduit

Wiring with this form of conduit is the best practice and the unlined conduit is now almost exclusively

FIG. 6. FLEXIBLE CONDUIT AND STEEL ARMORED CONDUCTORS

employed. The conduit is used simply to protect the wire from injury and the insulation of the wire itself is looked to for insulation. For the unlined conduit, double-braided rubber-covered wire must be used. and where the circuit is liable to dampness, the conduit should be galvanized, both inside and outside. The size conduit needed for different combinations of wire, is indicated in Table IV, p. 349, these sizes allowing for easy pulling of wires around 3 elbows.

Pull boxes, made of iron, or lined with iron may often be substituted for several elbows to advantage. The elbows used are bent at an angle of 90 deg., with a curve having a radius of not less than 3.5 in. for pipe of 1 inch or less, and 5 times the diameter of the pipe for larger sizes. The Underwriters' rules specify that these elbows must be made on purpose and not bent from lengths of pipe, the purpose being to avoid any roughness on the interior. All conduits must be continuous from one junction box or outlet to another and the tubes must properly enter fittings. The entire conduit system for a building must be put in place before wire is drawn in, and all ends of conduits firmly secured to their terminal and junction boxes, the metal of the system being effectually and permanently grounded.

When installing vertical risers in conduits, the wires should be supported within the conduit system as follows:

No. 14 to zero every 100 ft.; 00 to 0000 every 80 ft.; up to 350,000 circular mils every 60 ft.; from that to 500,000 circular mils every 50 ft.; 500,000 to 750,000 circular mils every 40 ft.; 750,000 and over every 35 ft.

In mill construction buildings with open beams, the conduit is generally run on the beams in the ceiling, and in fireproof buildings, it is usually run on the fire brick floors, the ends begin bent down through the fire brick to reach the outlet box on the ceiling below. All joints must be screwed together, and there must be no burs in the conduit.

For reinforced concrete buildings, sheet-iron tubes or pieces of conduit must be run through the floors and partitions where it is desired to install electric circuits. If conduit is used, the ends should be threaded so that pieces of conduit may be joined on. Where there is dampness, as in breweries or outdoors, lead incased wires should be used, if possible, and great care taken not to injure the lead casing when drawing the wire into the conduit.

Where a tap is to be taken off the leads for a fixture or a branch circuit, an outlet box is installed, and the best of these have knock-outs arranged so

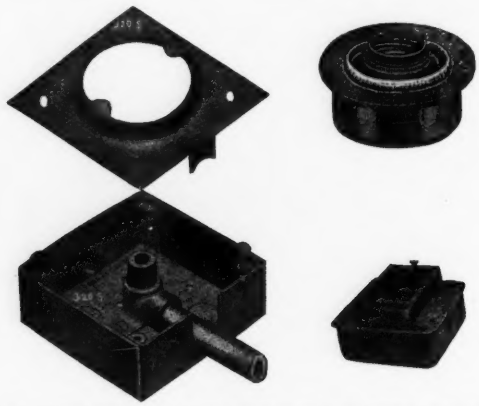


FIG. 7. OUTLET BOX, AND FITTINGS FOR RIGID CONDUIT

that the hole can be knocked through the shell of the box at any point needed, by the use of a hammer. Where the conduit comes into the box, a special bushing with set screws is used.

All cutout boxes should be set flush with the finished wall of the room, and the fixture put on outside. For running on open beams, a new type of outlet box has recently been devised which becomes a part of the conduit system, as it screws to the ends of the conduit at both ends, outlet being through the cover, or acts as a terminal to the line of conduit.

Where insulated conduit is used, the rules require that the lining must be firmly attached to the pipe, so that it will not break when a length of conduit is uniformly bent at a temperature of 212 degrees, to an angle of 90 degrees with radius 15 times the diameter of the pipe. This lining must be at least 1-32 in. thick and must not be mechanically weak after 3 days submersion in water, nor must it show any sign of cutting after drawing in and out wires several times.

A convenient device to be used in fishing is a long auger, carrying a cord for pulling in the wire inserted through a hole near the point of the auger. The wire can then be pulled through and the flexible tube threaded on after the wire is in position. When fishing in wire, the circuit should always be run from the bottom upward.

In all installations, the main point should be to see that the wires are so arranged that a ground cannot start on the circuit and that the wires of the circuit cannot become crossed to start an arc. Also

that all wires and parts of fixtures or apparatus are so fastened that they cannot come loose and make trouble.

Fixtures

When supported from the gas piping of a building, fixtures must be insulated from the gas piping system, by approved insulating joints, placed as close as possible to the ceiling, and the wires near the gas pipe, above the insulating joint should be surrounded with porcelain tubes, if possible. Where combination gas and electric fixtures are used, with the wire between the inside pipe and outer casing, at least ¼ in.

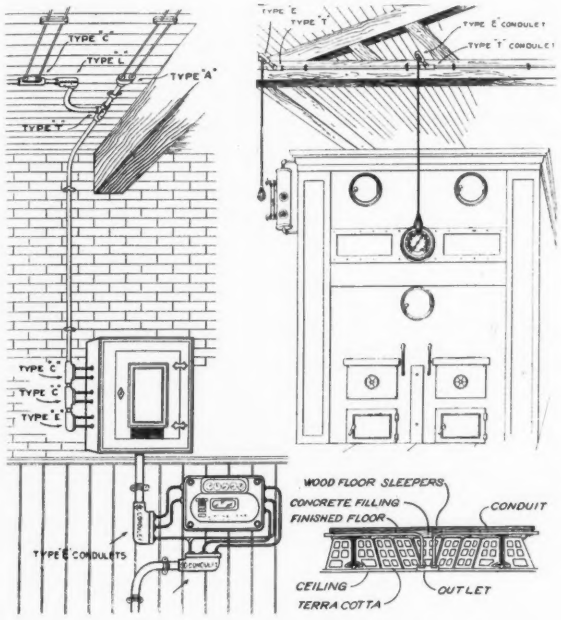


FIG. 8. EXAMPLES OF IRON CONDUIT AND CONDULET WIRING

space should be allowed between the pipe and the casing. Fixtures should be wired, with approved wires, either solid or stranded which have a solid insulation, at least 1-32 in. thick, and a slow-burning, tough outer covering. Number 16 is the smallest wire advisable for fixture work, although Number 18 is allowable in special cases.

When putting in a fixture the insulating tube should extend at least 3 in. beyond the plastering and a ceiling board or iron plate should be put under the crow foot of the fixture to prevent cutting into the plastering.

Flexible cord should not be used to support clusters or for anything other than single drop lights, wiring of fixtures, and for portable lamps. When used for portable lamps, it should have a special tough outer covering. Care should be taken that wherever lamp cord enters sockets or desk or stand lamps, an insulating bushing is provided and is in place.

When socket lamps and shades are carried by flexible cord, knots should be made in the cord, under the bushing in the socket and above the point where the cord comes through the ceiling block or rosette so that the strain may be taken off the joints and binding screws which make the electrical contact. Where the ends of flexible cord go under binding screws, they should be soldered to keep them from fraying out. In damp or wet places, special waterproof sockets should be used, with separate stranded rubber-covered wire, not smaller than No. 14, and these sockets should be keyless.

Knife switches for circuits should be mounted on insulating bases, with cross bars of insulating material or insulated from the blade. The blade must have thickness and enough metal so that the rise in temperature of any part will be not over 50 deg. F. at full load. The bearings should be thoroughly good, and with area of contact surfaces of about 1 sq. in. for each 50 amp. Knife switches should be so installed that the handle will be up when the circuit is closed.

Where flush switches are used, with conduit system, the switches should be enclosed in boxes consisting of or lined with fire resisting material and where several switches are placed under the plate, the box should have a separate compartment for each switch.

Snap switches should be mounted on slate or porcelain bases and indicate whether the current is on or off. They should be so made that they cannot stop between the off and on point when started.

For fusing a circuit, porcelain cutout blocks should be used with porcelain covers, and enclosed fuses are always to be preferred where the current is over 5 amperes. For such cutouts and for knife switches, terminals should be separated at least ¾ in. for 10 amperes and 1 in. for more than this up to 300 amperes, these values being for 125 volts or less. For 125 to 250 volts, this should be, for 10 amperes, 1.5 in.; from 11 to 100 amperes, 1.75 in.; and for 101 to 300 amperes, 2 in.

TYPES AND PERFORMANCE OF TRANSFORMERS

ONE of the principal advantages of an alternating current over direct current is the ease with which voltage may be changed to any desired value, with but a small amount of energy lost in transformation. This change is made by means of transformers which have no moving parts and require almost no attention.

Types

According to winding, transformers may be classed as either core or shell type, and according to the methods of cooling, as oil, air, or water-cooled type.

In core-type transformers the iron forms one magnetic circuit which is not divided, and the coils are wound around each leg of iron, as will be seen in Fig. 1. All transformer cores are made of well-annealed soft iron, laminated to cut down eddy currents. The coils are at least 4 in number, one high and one low-tension coil on each leg; they are always form wound, and present the advantage of being replaced easily in case of a burn-out. This type of transformer is cheaper than the shell type owing to the simplicity of construction and relative small amount of copper.

Transformers of the shell type may be said to be the reverse of the core type, that is, the iron and copper circuits change places. The winding of these transformers consist of a series of pancake-shaped spiral coils, which are wound alternately for high and low tension and assembled as shown in Fig. 2, the number

being limited by the size of the transformer. This arrangement of coils gives better regulation but requires relatively more copper than the core type and requires a great deal of labor in replacing damaged coils.

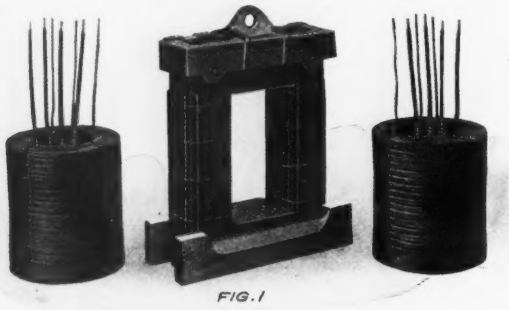


FIG. 1

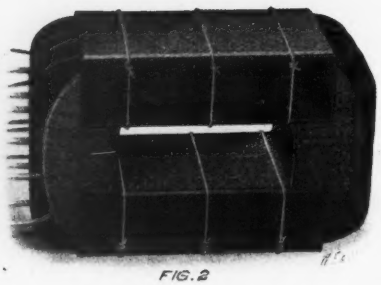


FIG. 2

FIG. 1. WESTINGHOUSE CORE TYPE TRANSFORMER
FIG. 2. ASSEMBLED COILS FOR WESTINGHOUSE SHELL TYPE TRANSFORMER

Nearly all lighting transformers are wound with taps from the high-tension coils, which will allow the low-tension voltage to be raised 5, 10 or 15 per cent, and thus provide for drop on the line.

Cooling

The losses in a transformer are dissipated in heat and in order to keep the temperature down to a reasonable degree it is necessary to employ some means for increasing radiation. Air-cooled transformers depend upon a draft of air passing up through the coils and around the core to carry off excess heat. In small size transformers of this class, the natural draft is sufficient, but in those of large capacity it is necessary to use some means of forcing the air.

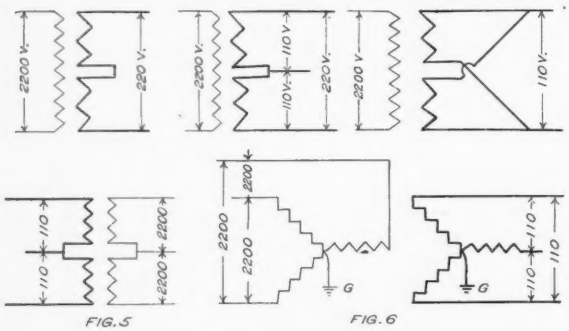


FIG. 4. SINGLE-PHASE TRANSFORMER CONNECTIONS FOR 2 OR 3-WIRE SYSTEMS
FIG. 5. 2-PHASE 3-WIRE TRANSFORMER CONNECTIONS
FIG. 6. 3-PHASE STAR CONNECTION WITH GROUND

Oil-cooled transformers are the most used for lighting purposes and are provided with oil-tight cases of sheet or cast iron, usually corrugated to present more radiating surface. Oil is a better conductor of heat than air, and natural circulation is maintained up through the coils and down near the sides of the case, the oil heated by the coils being cooled in its downward course by contact with the case. The oil has the advantage of being a good insulator, and thus reduces the liability to insulation breakdown. It also prevents corrosion by keeping the moisture of the air from coming in contact with the coils or iron.

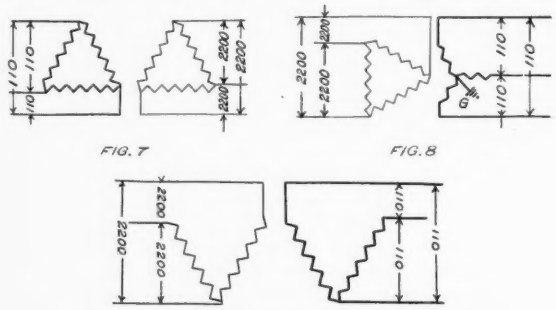


FIG. 7. 3-PHASE DELTA CONNECTION
FIG. 8. 3-PHASE DELTA-STAR CONNECTION
FIG. 9. OPEN DELTA OR V

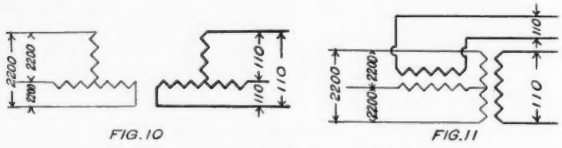


FIG. 10. 3-PHASE T CONNECTION
FIG. 11. 3-PHASE 2-PHASE CONNECTIONS

In the case of large station transformers it becomes

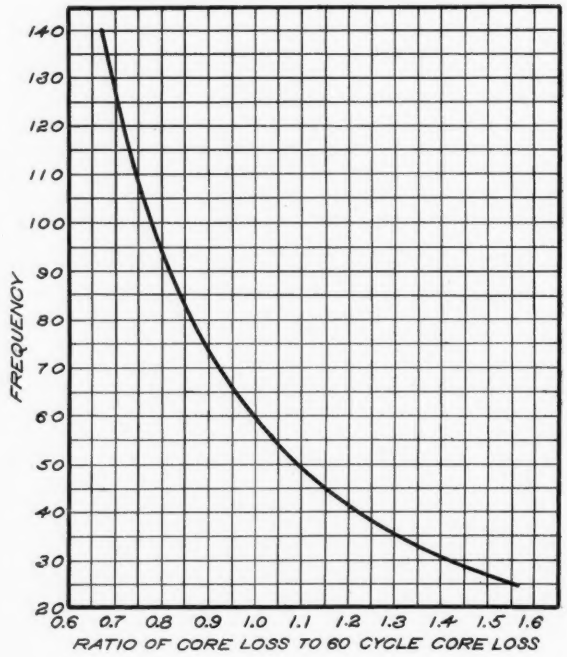


FIG. 12. EFFECT OF CHANGE OF FREQUENCY

necessary to employ an artificial means for the radiation of the heat and this is done by surrounding the transformer coils with water pipes, through which cold water is passed, thus cooling the oil to a lower degree than can be done by natural radiation through the walls of the case.

In all these methods the transformers are made with ducts or radiating spaces running vertically,

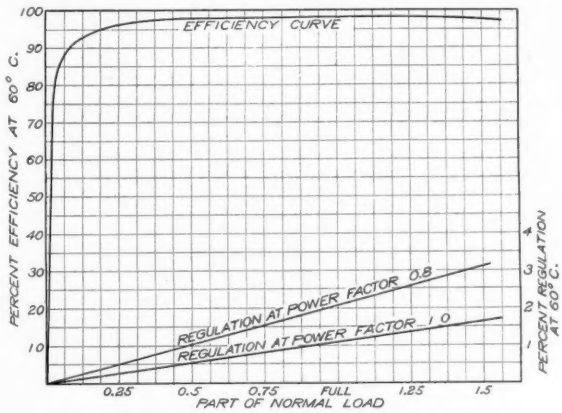


FIG. 13. EFFICIENCY AND REGULATION CURVES

which allow the greatest possible radiating area to the interior of the coils and core so as to prevent hot spots, which would cause deterioration of insulation.

Connection

Single-phase transformers are usually made with 4 low-tension leads, brought out of the case, which permit them to be connected for either of 2 different voltages or the 3-wire system, the connections being made as shown in Fig. 4.

As a general rule, the 2-phase circuit consists of 4 wires, but when it is desired to employ the 2-phase 3-wire system 2 transformers are necessary, which may be connected as indicated in Fig. 5, the advantage of this system being a saving in copper.

For transforming voltage on a 3-phase system, it is customary to employ 3 transformers connected in star with a grounded neutral, as shown in Fig. 6, or in delta with connection and voltage ratio, as indicated in Fig. 7. These 2 are the usual methods employed in 3-phase transformation, but the delta-star connection with grounded neutral is sometimes employed to lessen the danger to workmen on the secondary line. This arrangement is shown in Fig. 8. Three-phase transformers are manufactured which are all contained in one case and may be obtained with any of the standard 3-phase connections which have been described.

The open delta or V connection, shown in Fig. 9, is the result of removing one transformer from the delta 3-wire system, the effect being only to increase the load on the remaining transformers. When only 2 transformers are available, and the 3-phase system is employed, the open delta connection is a convenient method of obviating the difficulty, or the T connection may be employed if one of the transformers has taps on both windings, making the number of turns in actual service 87 per cent of those in the other transformer. This connection with the voltage ratio is shown in Fig. 10.

A modification of the T connection is the 3-phase 2-phase system of transformation shown in Fig. 11, which requires transformers of the same winding as for the T system.

Change of Frequency

Extensive improvement in the powerhouse equipment, frequently necessitates a change of the frequency of the system. The effect of this change of frequency upon the core loss of transformers on the line is shown by the curve in Fig. 12. It will be noted that as the frequency increases the core loss decreases, due to the fact that owing to magnetic lag the iron does not reach to the same point of saturation and therefore does not consume so much power.

The efficiency of transformers is highest at the rated full load for which they are designed and decreases as the load varies either way from this amount, this relation being shown by the curve in Fig. 13. Transformer regulation is directly proportional to the load and the power-factor of the circuit as is shown in Fig. 13 by the 2 straight line curves, the regulation being understood as the per cent rise in voltage of the secondary by removing the load while maintaining the primary voltage constant.

TRANSFORMER TESTS

RATIO and polarity tests should be made on all lighting transformers before they are put into service to make sure that these conditions are correct.

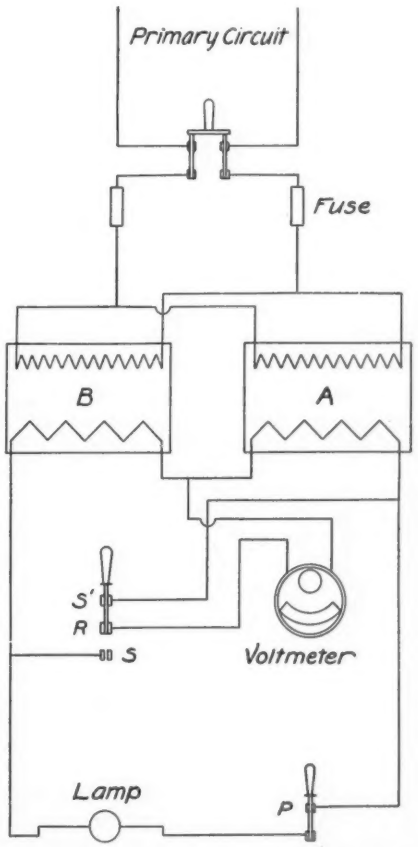


FIG. 1. CONNECTIONS FOR RATIO AND POLARITY TEST

The ratio should be absolutely exact, otherwise the delivered voltage will be either too high or too low, causing short lamp life or low candlepower. Correct ratios are always essential in multiple connections of transformers, otherwise cross currents will exist, caus-

ing undue heating and eventually the burning out of some of the transformers.

The connections for measuring the ratio and polarity tests are shown in Fig. 1. For the ratio test the small switch P, controlling the lamp, is left open, close the secondary switch R to the volt meter first to S and then to S'. If the standard transformer has the same ratio as the transformer under the test, the 2 voltages will be the same.

By the polarity of 2 transformers being the same is meant that the instantaneous direction of current in the leads joined must be relatively the same. This is a necessary condition which must be taken into consideration when connecting 2 or more transformers in parallel.

For making the test which is here described a transformer whose exact ratio and polarity are known should be available. In Fig. 1, A is the transformer under test and B a transformer of standard ratio and

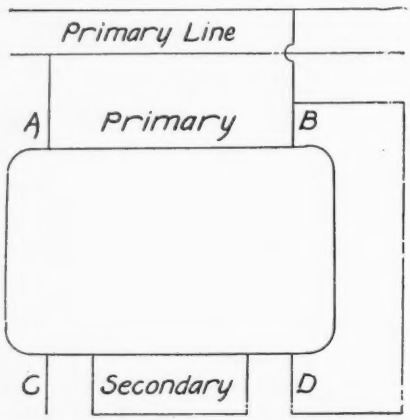


FIG. 2. POLARITY TEST CONNECTIONS

polarity. The secondaries of the 2 transformers are connected in series and to their common connection 1 terminal of the voltmeter is connected, the other voltmeter terminal being connected to the central point of the single-pole double-throw switch. One or more incandescent lamps in series, whose combined voltage is equal to the total voltage of the 2 transformers, are connected across the secondary leads of the transformers to determine the polarity.

The polarity test is taken with the switch R open and the small switch P closed, putting the lamp in circuit, then close the main switch and if the lamp lights up the polarities of the 2 transformers are the same.

If a standard transformer is not to be had, the ratio of the transformer under test may be checked by simultaneous reading of the primary and secondary voltages. This method, however, is not preferable, as to get an accurate determination of the ratio this test can be made only with carefully calibrated instruments.

To test the polarity of a transformer when no standard transformer is at hand the connections are made as shown in Fig. 2. If the voltage between A and C is more than the primary voltage, the polarity is correct. If less than the primary voltage, the leads should be brought out of the case in the reverse order.

Heat Tests

Perhaps the most important test of transformers is the heat test, as the temperature at which the transformer operates determines largely its output, life and efficiency. Higher operating temperature causes deterioration of insulation, increased core loss due to rapid aging of the iron, and increased copper loss due to increased resistance.

To obtain the temperature rise, which should never be more than 90 deg. F. for continuous service, the transformer is operated with full-load current of proper frequency until the temperature becomes constant, which is usually about 8 hr. for lighting transformers.

One method of conducting this test is to supply the transformers with a load of lamps or other resistance, maintaining the rated voltage and frequency.

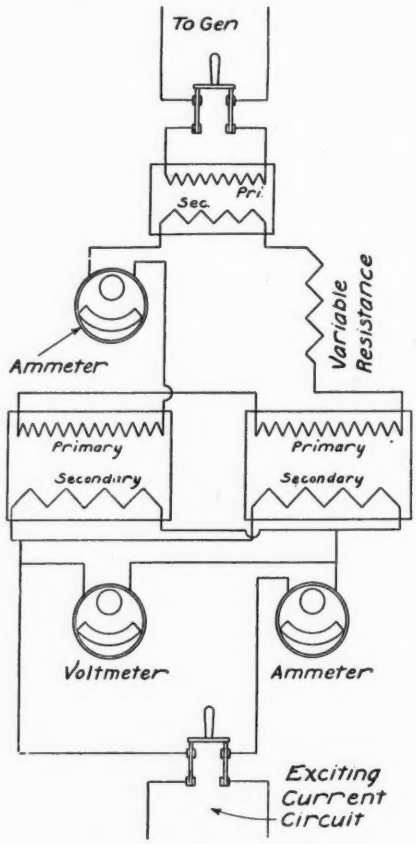


FIG. 3. LOADING BACK METHOD OF HEAT TEST

This method, however, is not advisable except on small transformers, as the consumption of power is a considerable loss.

The loading back or opposition method is the one most generally employed, the advantage of this method being that the energy consumed during the test is only that due to the losses in the transformers. Therefore, this method may be used with transformers of large capacity with very little loss of energy.

The connections for this test are made as shown in Fig. 3, with 2 transformers having the same voltage, ratio and as near the same capacity as possible, excited from a circuit of proper voltage and frequency thereby inducing normal voltage in each primary. The 2 primaries are connected in series but in opposition, thus making their combined voltage zero.

It will be seen with this connection that by applying approximately the sum of the impedance voltages

of the transformers across the primary will impress a full-load current in both primary and secondary winding. This impressed voltage may be applied from a small auxiliary transformer, having a lamp bank or other suitable resistance in the secondary by which the voltage may be adjusted until full load current flows in both windings. Before commencing the test on the transformers they should be filled with oil and then placed in the room where the test is to be carried on for a time long enough for them to attain the temperature of the room.

For taking the temperature readings, 3 accurate thermometers are necessary, one to be suspended in the room, one in the oil surrounding the transformer coils, and one with the bulb secured to and in contact with the outside of the transformer case by putty, waste or a string. The temperatures as indicated by the thermometers should be read and recorded every half hour and the resistance of the primary and secondary coils measured every half hour alternately as described in our April issue under the subject of Copper Loss. The temperature rise of the windings may be determined by dividing the difference between hot resistance and cold resistance by the cold resistance, the result being the temperature rise in degrees Centigrade.

The core loss, exciting current and copper loss should be taken before and after each run. The core loss and exciting current should be less at the end of the run than at the start. If this is not the case, the transformer is either not well insulated or it is not thoroughly dried out.

If the core loss increases instead of decreases at the end of the run, it would be well to measure the insulation resistance, to determine the condition of the insulation.

The insulation resistance of a well insulated and thoroughly baked transformer should not be less than one megohm from primary to secondary or from primary or secondary to ground.

The insulation test is made by connecting a volt meter in series with the resistance which is to be measured, and the insulation resistance is then calculated, being equal to the total line voltage less the voltmeter reading between the winding and ground or between primary and secondary multiplied by the resistance of the voltmeter, and this result, divided by the voltmeter reading between the winding and the ground or between the primary and secondary, the result being insulation resistance in ohms.

The regulation of a transformer with a load of a given power factor is the percentage of difference based on a full load voltage between the full load and the no load secondary voltages with a constant applied primary voltage. It may be ascertained by applying full load to the transformer and noting the secondary voltage then removing the load and noting the secondary open circuit voltage. For both these readings the primary voltage must be held at a constant value. The primary voltage may be observed on the voltmeter which is connected through a voltage transformer to the line. It is difficult to get satisfactory readings in making this test for the reason that the rise in voltage between the full load and no load is usually very slight.

The drop in a secondary voltage will be very much greater with an inductive load such as arc lamps or induction motors than it will be with incandescent lamps. Regulation test for loads having any power factor may be made in the same manner as given above, by substituting arc lamps for some or all of the incandescent lamps. In this case it will be necessary to use either a wattmeter or a power-factor meter, if it is desired to determine the power factor of the load.

The efficiency of a transformer is the ratio of its net power output to its gross power input, the current being measured with a non-inductive load. The power input includes the output plus the core loss and the resistance loss on both primary and secondary windings at a given load on the transformer. The copper loss by the wattmeter method may be used instead of the resistance loss in calculating the efficiency.

The total losses of a transformer are made up of a constant loss or the core loss, and a loss which varies as the square of the current or the copper loss.

The important problem to the plant engineer in selecting his transformers is to secure transformers with a high all-day efficiency. By this is meant the ratio of the output to the input during the entire 24 hr. In order to draw up specifications for transformers which will give the highest all-day efficiency, it is necessary to know the conditions under which these transformers will be operated. Then in the design of the transformer, the manufacturer can vary the losses due to iron and copper in such a proportion as to give the highest efficiency for the entire 24 hr.

SWITCHBOARDS FOR ISOLATED ELECTRICAL STATIONS

IN ISOLATED electrical stations if there is any one part of the equipment which is incomplete, it is usually the switchboard. This probably is due in a great measure to the high initial cost of switchboard instruments and a lack of appreciation of the value of such instruments as are not an absolute necessity in the operation of a plant.

In the layout of the plant, one should keep in mind that the switchboard should present a means of controlling the entire electrical equipment of the station. The instruments, switches and controlling devices should be sufficient and so compact that 1 man can keep in touch with the complete station at all times. In order that best economy may be obtained, it is necessary that a record of the output should be kept and the most convenient location for such recording instrument is upon the switchboard. Another function of a switchboard is to supply a means for protecting the expensive apparatus of the plant from damage due to overload, short circuit, lightning, etc.

Location

It is well to locate the switchboard where the operator will have a full view of the generators and the prime movers, which gives him an idea as to the mechanical condition of the apparatus.

Where remote control switches are employed, as is the case in some stations which have high-tension primary equipment, they should be kept away from the switchboard containing the instruments as far as possible, as the danger of fire in high-tension oil switches is considerable.

Ample space should be allowed in front and behind all the switchboards to permit access to any part of the wiring without danger of shock. In the original layout, plenty of space should be allowed for the ex-

tension of the switchboard and connecting cables as the plant grows to meet the greatest demands that are likely to be made upon it.

Equipment

While all switchboards are special to a certain extent, that is, they must have special consideration in their design to suit the local conditions, there are several general types of switchboard which are almost standard for isolated stations.

The apparatus recommended for use on a direct-current generator panel for voltage up to 250, 2-wire system consists of 1 carbon tip circuit breaker with bell alarm switch, 1 ammeter with a capacity equal to 150 per cent of the rating of the generator, 1 hand wheel for operating the field rheostat contact arm, 1

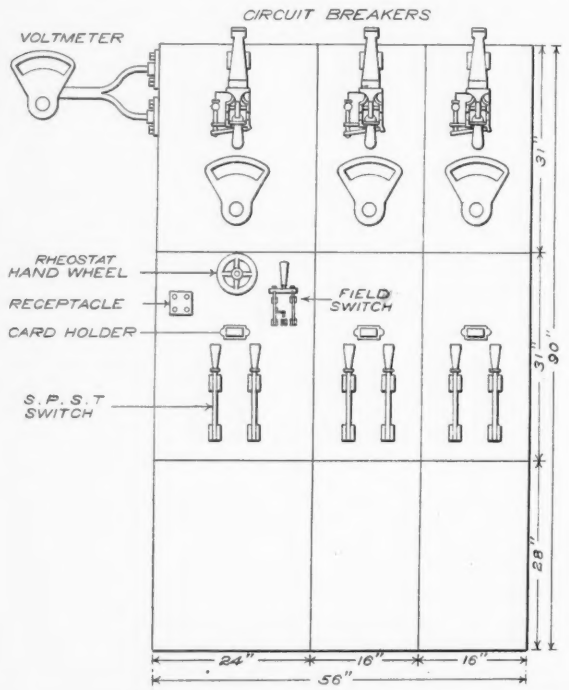


FIG. 1. ARRANGEMENT OF INSTRUMENTS FOR A DIRECT CURRENT GENERATOR AND FEEDER PANELS

single-pole single-throw field switch with discharge clip, 1 4-point voltage plug receptacle, 2 single-pole single-throw lever switches and a voltmeter, usually hung upon a swinging bracket at the end of the board.

The feeder panel which is used in a direct-current station should consist of a single-pole circuit breaker with bell-alarm switch and an ammeter, together with 2 single-pole switches, one of which may be omitted, the remaining switch being connected in one side of the circuit and the circuit breaker in the other. A good arrangement of instruments on a direct-current board is shown in Fig. 1.

When an alternating-current system is employed it is preferable to have the exciter switchboard in a separate panel, thus making it easier to dispose of the entire outfit should a change be made in the station equipment. This also permits a more systematic arrangement of the instruments and other devices and a smaller panel for the generator can be used.

Where this panel is employed the equipment recommended for use is the ammeter, a field rheostat hand wheel, a single-pole, single-throw switch and a 2-point potential receptacle. Where more than 1 exciter is used, 1 voltmeter mounted on a bracket at the end of the board will serve the purpose desired. Negative and equalizer switches mounted on or near the machine should be employed where the exciters are run in parallel. A fuse on the back of the board is also necessary for protection to the exciter.

When a 2-phase, 2,200-volt generator is employed, the equipment of the panel consists of 2 ammeters, 2 indicating wattmeters, a field ammeter, a voltmeter, a single-pole single-throw field switch with discharge clip, a rheostat hand wheel connected to the mechanism for field control, a 6-point potential receptacle and 4-point plug, a 4-pole single-throw oil switch, 2 current transformers, 2 potential transformers and a power factor meter. When several of these generators

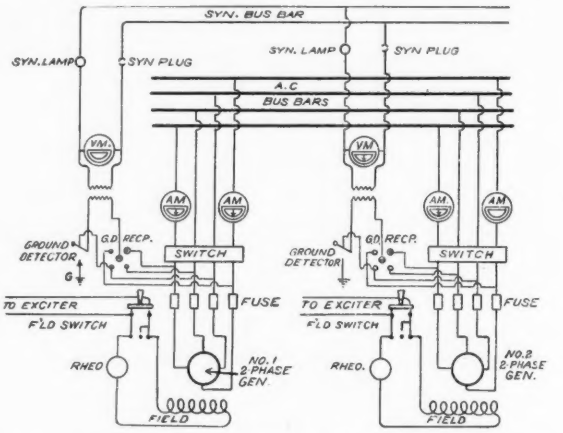


FIG. 2. SWITCHBOARD DIAGRAM FOR A 2200-VOLT 2-PHASE SYSTEM

are to be run in parallel, to this equipment should be added a 4-point synchronizing plug receptacle and a synchroscope or synchronizing lamps.

Figure 2 shows the connections for this class of switchboard.

Switchboard Material

The materials used for switchboard panels are white Italian marble, blue Vermont marble and slate. For this purpose they are carefully selected and should be free from flaws, streaks and conducting veins. The qualities which combine to make these materials used so extensively for switchboard panels are that they are moderately good insulators, strong, can easily be obtained in any desirable size, are comparatively low in cost, easily worked, perfectly fireproof and present a neat appearance. The objection raised against any of the marbles for this purpose is that they become soiled easily and an oil spot, which cannot readily be removed, spreads and makes a bad stain. Slate panels are strong but are less homogeneous than the marble and are always given an artificial polish.

The standard sizes of switchboards vary a great deal with the manufacturer, but for the average case, where there are 3 sections to the panel, the top is about 31 in., the middle section is also 31, while the bottom section is 28 in. high. The width varies from 16 to 31 in.

Installation

The unpacking of a switchboard should be done very carefully and in a dry place. The various parts

of the instruments and apparatus should be placed aside where they can readily be obtained by the workmen, but should be kept away from irresponsible persons around the plant.

A firm foundation should be made for the switchboard of either hard wood or iron. Where the system is to be grounded, the panels should be insulated. For this purpose a wood sill 1.5 or 2 in. thick will answer very well. It is important that the foundation and location of the switchboard be such that no vibration from the generator or engine is transmitted to the switchboard as the instruments are delicate and any jarring would tend to wear them out rapidly.

The supports and framework are put together but not bolted rigidly until after the panels are put in place. The panels are then arranged in their proper order and bolted loosely to the supporting irons; when

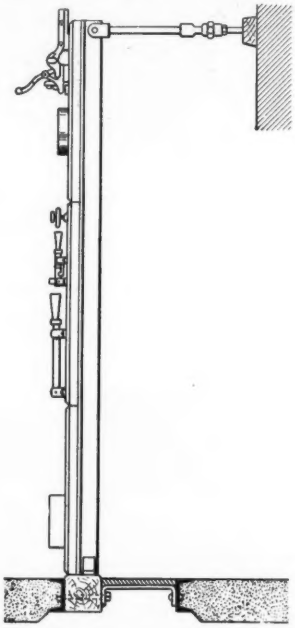


FIG. 3. PANEL SUPPORTED ON ANGLE IRONS

all are in their proper positions the bolts are tightened, using thin paper or fiber washers between the iron and the stone work. The various devices are then placed upon the board, the final leveling and plumbing are done and the board securely fastened in place. Fig. 3 shows a substantial method of installing a switchboard.

Wiring and Connections

The wiring and connections on the back of the panel are made strictly according to the diagram furnished by the manufacturer and should not be varied in the slightest detail unless the wireman is thoroughly familiar with every electrical detail of the plant. All wiring should be done in a safe manner using nothing but fireproof insulation, spacing the high-tension wiring at least 4 times the sparking distance in air.

Special attention should be given to the joints, whether bolted on studs or soldered wire joints, to see that they are clean and free from burrs. In the wiring of a switchboard all sharp bends should be avoided. An alternating-current conductor carrying a heavy current should not run near the iron work or any instrument, as it is likely to cause heating by the inductance set up. Special conductors should be used where heavy currents are employed, as large cables are not suitable for a high current density.

Leads from the instrument transformers should run close together to avoid induction; cables of the double or triple type are very good for this purpose. Long-distance instrument connections should be run in lead-covered cables or in iron conduit.

All wire and bus bars should be carried on rigid supports and insulators; all joints should be thoroughly taped and accessibility aimed at in all cases. When bare conductors are used as is the case with high-tension work, distance alone is relied upon as an insulator. It is recommended that all compartments where switches or fuses are situated be thoroughly fireproof and that the doors into these compartments be hinged at the top and not fastened so that, if an explosion occurs, it will not injure the whole compartment but merely blow the door open and allow the gases to escape.

Operation

Before the switchboard is put into use, the engineer should check over and test out carefully for open or short circuits. He should also test the instruments to see that they record or read in the right direction. It would be well, too, if he could run the switchboard on short circuit for an hour or two in order to show up any loose joints or other defective work in the switchboard wiring. Where the apparatus is for use on a system carrying above 2,300 volts, a potential test of about 3 times the normal voltage should be put upon the board.

After these preliminary tests have been made, the board is ready to be turned over for actual service test. All joints and details should be watched carefully and a regular system of inspection should be practiced at all times, examining closely all joints in cables, buses, connection bars, the temperature of instruments and other apparatus, insulation and all moving parts.

Every precaution should be taken by the operator to avoid receiving an electric shock from the board, for, even if the voltage is not high enough to injure him, the sudden shock may cause him to throw a screw driver or wrench across the terminals of the machine and thus cause considerable damage to the generator. For this reason the switchboard should be made dead if possible, when it is found necessary to work upon the wiring, but if not possible, rubber gloves will answer very well up to a voltage of about 2,300, above which no risk whatever should be taken. No instrument or device used on a system of 600 volts or above should be considered safe to touch unless it be grounded.

Before starting up a generator, all switches and circuit breakers should be opened. When the generator and exciter have attained their normal speed, the field switch of the generator should be closed and the voltage raised to normal by operating the rheostat hand wheel. In throwing the load upon the generator the circuit breaker should be closed first and the main switches afterward. In opening a circuit, always open the circuit breaker before the knife switch is opened.

All instruments should be regularly and carefully tested for accuracy, and inspection of all switches and circuit breakers, relays, etc., should be made regularly. Oil switches should have good contact with no sticking; the proper amount of oil should always be in the case and inspection after each short circuit or severe overload is very important. The oil used in switches

should be only that which is recommended by the manufacturers and this should be filtered occasionally to remove all carbonized particles which may be caused by short circuit or otherwise. The carbon tips of the circuit breakers should be kept in good order and tests made frequently to see that the breaker opens at the desired point. For keeping the back of the panel clean a pair of bellows or compressed air will serve well and eliminate the possibility of a short circuit.

SWITCHBOARD INSTRUMENTS

INSTRUMENTS used on switchboards in power plants are not in general as delicate or accurate as instruments used for testing purposes in laboratories. The electrical principles upon which these instruments work are, however, the same as those employed in the testing instruments, with modification in mechanical design to suit the service for which they are intended.

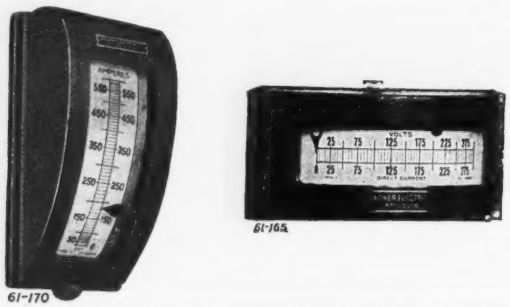


FIG. 1. VERTICAL AND HORIZONTAL SCALE WAGNER ELECTRIC CO. INSTRUMENTS

These instruments are calibrated to give readings accurate within 2 or 3 per cent, which is consistent with all good practice in power plant work. On most instruments cast-iron cases are used, which prevent dust from accumulating on the working parts and also protect them from the stray field set up by the current in the switchboard wiring, bus bars, etc. Nearly all manufacturers of voltmeters and ammeters make them with circular, vertical or horizontal dials, the choice being largely a matter of fancy with the purchaser, or arrangement of the board.

Voltmeters and Ammeters

There is little difference between the construction of a voltmeter and an ammeter, this being chiefly in resistance. Voltmeters are used to indicate any potential difference between points on a line, and are provided with a scale, over which a light pointer swings indicating this difference in volts. A high resistance is always placed in series with the voltmeter which allows only a small current to pass through the instrument. This current will vary directly as the potential difference and the deflection of the needle is proportional to the current and consequently to the voltage.

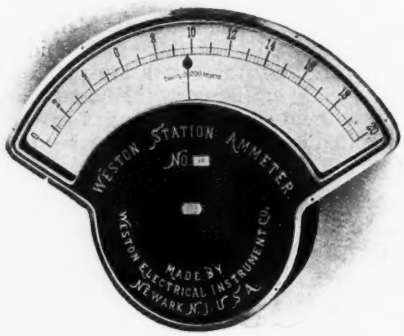


FIG. 2. ILLUMINATED DIAL INSTRUMENT MADE BY THE WESTON ELECTRICAL INSTRUMENT CO.

Switchboard voltmeters for direct current are connected directly across the line with a high resistance in series with them, this resistance varying in proportion to the voltage of the circuit. Voltmeters for alternating-current circuits are usually attached to instrument transformers which reduce the voltage of the main circuit to that suitable for the instrument, except when the voltage is low.

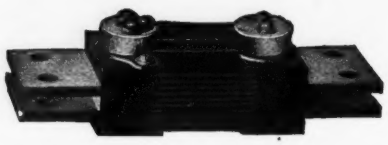


FIG. 4. FORMS OF AMMETER SHUNTS OF THE GENERAL ELECTRIC CO. MAKE

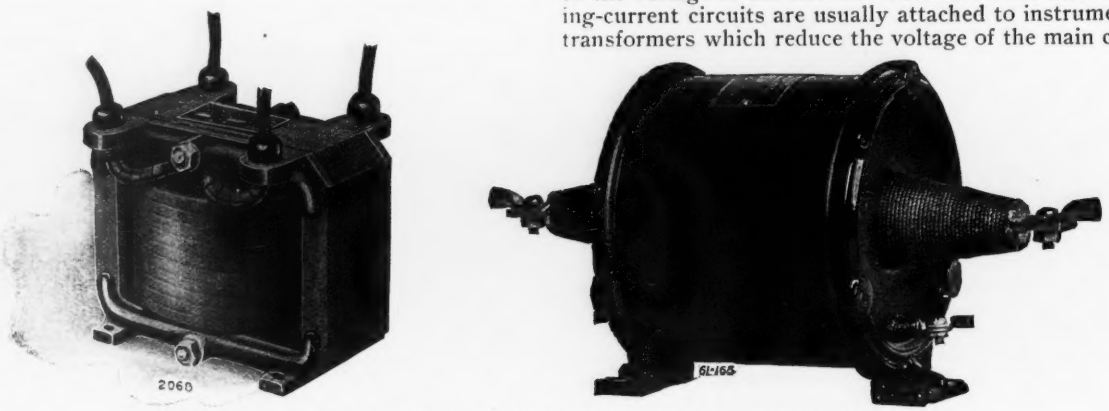


FIG. 3. WAGNER ELECTRIC CO.'S VOLTAGE AND SERIES TRANSFORMERS

Ammeters must be connected in series with the main circuit and it is desirable that their resistance should be as low as possible so that the energy consumed will be slight. The scale of the ammeter is graduated to indicate amperes direct.

Ammeters used on direct-current circuits are usu-

ally placed in series with the line or in parallel with a German silver shunt when the current is too heavy for the ammeter. Alternating-current ammeters are connected in series with the circuit when the load is

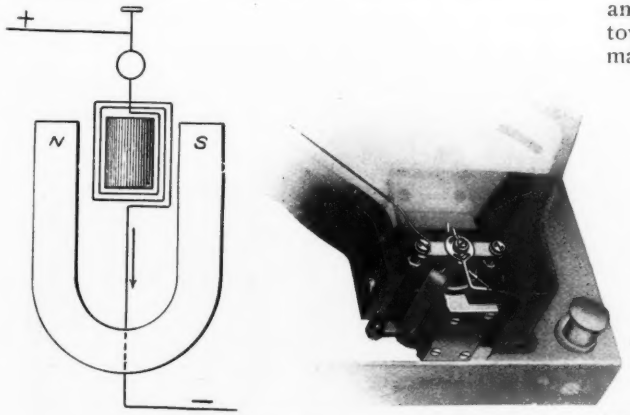


FIG. 5. D'ARSONVAL GALVANOMETER
FIG. 6. MOVEMENT OF WESTON INSTRUMENTS

not too great, in which cases a series transformer is employed with the ammeter in series with the secondary winding.

Switchboard meters are the outgrowth of the early forms of galvanometers, and their operation will best be understood by a detailed description of these primitive instruments.

Galvanometer Principle

Nearly all electrical measuring instruments depend upon the principle that a conductor carrying a current of electricity induces a magnetic field in the medium around it. The presence of this field causes a magnetic needle supported upon a pivot to take a certain definite position, depending upon the direction of the current and its magnitude. The d'Arsonval galvanometer is an early form of current measuring instrument which is used extensively in laboratory practice and its principle, in modified forms, is employed in many switchboard meters.

This instrument consists of a permanent horseshoe magnet, NS, Fig. 5, between the poles of which is suspended a coil of fine wire wound over a rectangular frame, within which is a cylindrical soft-iron core that serves to concentrate the lines of force passing between the poles and thereby produces a firm magnetic field in which the coil moves.

The coil is adjusted so that its axis is at right angles to the flux of the permanent magnet, and is held in that position by a thin platinum silver wire. The current is passed into and out of the coils through 2 of these wires and a small concave mirror is usually carried upon the coil so as to reflect a ray of light upon a scale, the deflection of the coil being thus determined accurately.

The tendency of the coil to turn so as to include the greatest number of lines of force, when the current passes through it, is resisted by the torsion of the platinum wire. The deflection produced is directly proportional to the current, the number of turns in the coil and the intensity of the magnetic field. These principles are applied only in direct-current instruments, as in the alternating-current circuit the induction of the iron core is so great as to make the instrument inaccurate.

Inclined Coil Meters

The Thomson inclined-coil meter is extensively used in switchboard practice, its essential parts being shown in Fig. 7. A coil of fine wire A is fastened at an angle of 45 deg. with the base and inclined directly towards the scale. A vertical spindle of nonmagnetic material extends through the opening in the coil and

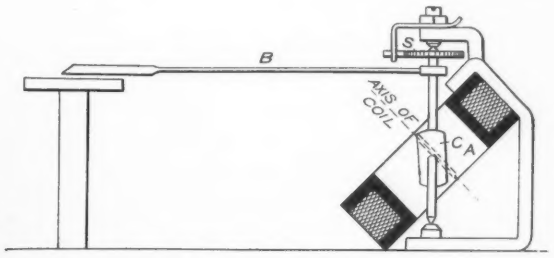


FIG. 7. THOMSON INCLINED COIL METER

terminates in steel points resting in jeweled bearings; on this spindle and at the center of the coil is a piece of soft iron, C, also fixed at an angle of 45 deg.; the pointer, B, is attached to the spindle in the ordinary manner, and a single spiral spring serves to give the mechanical reaction.

When a current goes through the coil, A, the soft iron vane tends to set itself in line with the flux of the coil. This motion is resisted by the spring and the

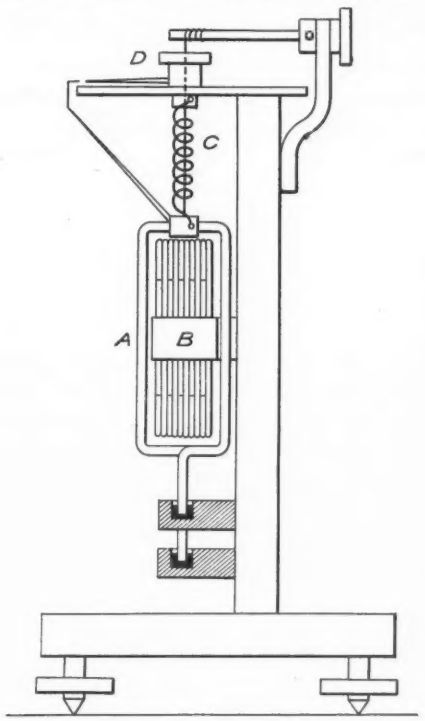


FIG. 8. SIEMENS DYNAMOMETER

movement of the pointer, B, over the scale is proportional to the current or voltage of the circuit.

Wattmeters

The power consumed in a direct-current electric circuit is equal to the current in amperes multiplied by the voltage, the product being in watts, and therefore

instruments which indicate the power consumed must take into account these 2 elements, voltage and current.

Indicating wattmeters on a direct current switchboard are hardly necessary as the voltage is generally carried constant and the operator can readily tell when the machinery is overloaded. In alternating-current circuits, however, where a great deal of inductance is present, the power factor of the circuit must be taken into consideration and in these cases it is advisable to employ an indicating wattmeter.

Dynamometer Principle

An instrument for this purpose is a modification of the Siemens dynamometer which is shown in Fig. 8.

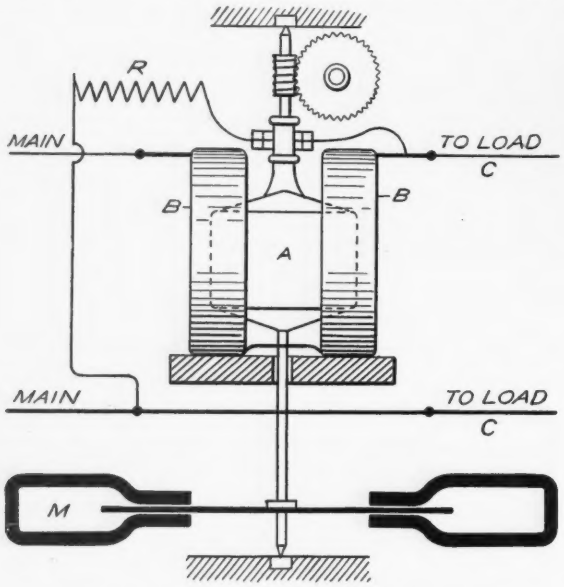


FIG. 9. THOMSON RECORDING WATTMETER

This instrument was designed originally to measure the strength of the current by the mutual action of 2 coils, A and B, at right angles to each other, through which the current passes in series. One of the coils A is movable and is supported by a pivot bearing. A coiled spring C is attached to this coil and to the torsion head D.

Current is introduced through mercury cups in which the terminals are immersed. This coil carries a pointer which extends up and over a circular scale, the torsion head carries another pointer so that when the current is passed through the coils the movable one tends to move so as to include the greatest number of lines of force and to set itself parallel to the fixed coil. The torsion of the spring opposes this movement and the torsion head is then turned until this exactly counterbalances the turning movement of the coil, which is indicated when its pointer is at the zero reading of the scale. The angle through which the torsion head is turned is indicated by its pointer and varies as the square of the current strength. The scale may be graduated to read directly in amperes. This instrument is very accurate and may be used on either direct or alternating current.

The dynamometer may be used as an indicating wattmeter by having one of the coils wound with very fine wire of high resistance and placed across the circuit thus taking current in proportion to the voltage, while the other is of coarse wire and placed in series with the line to carry line current. The scale must then be graduated to indicate watts. It will indicate correctly whether used on a direct or alternating-current circuit as the pull on the movable coil is proportional to the phase relation between the current and the voltage as well as to current and voltage.

Recording Wattmeters

Recording wattmeters are employed extensively in both direct and alternating-current circuits and are

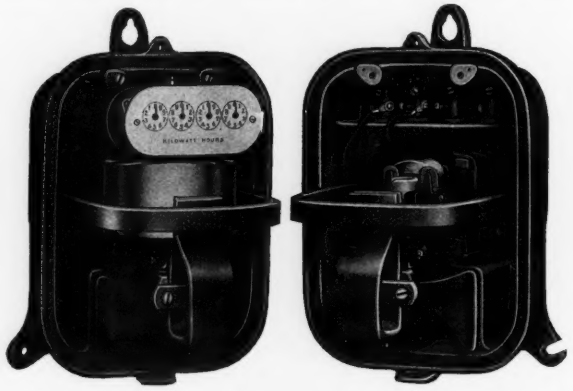


FIG. 10. FORT WAYNE INDUCTION WATTMETER WITH CASE REMOVED

frequently placed upon the generator switchboard to sum up the total amount of power used in the plant. This instrument does not record watts but watt-hours and thus gives a means for determining the exact amount of energy used during any given time.

Perhaps the most common form of this instrument is the Thomson recording wattmeter, a diagram of which is shown in Fig. 9. This instrument is in reality a motor without iron in the fields and consists of 2 coils, B B, wound with heavy wire, which are placed in series with the load. The armature A is of the drum type and operates on jeweled bearings. In series with the armature is a high resistance R, which, together with the armature circuit, is placed across the line and forms the potential or voltage circuit.

On the spindle above the armature is placed a commutator, upon which silver-tipped brushes operate

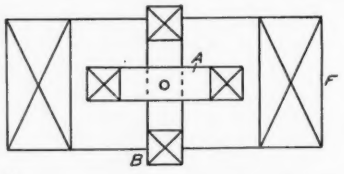


FIG. 11. DIAGRAM OF SYNCHROSCOPE

and above this a worm gear operates the recording hands over the dial of the instrument. Upon the armature spindle, attached firmly to it, is a copper disk which revolves between the poles of 2 permanent magnets, which makes the construction of the instrument such that the speed of the armature is proportional to the torque that drives it. Therefore, the rate of turning of the armature is proportional to the rate at which energy is delivered to the circuit.

Synchroscope

The synchroscope is an instrument used to indicate when 2 alternating-current generators are in synchro-

nism, thus facilitating the operation of synchronizing them. This instrument is built on the principle of an induction motor, all the parts being similar in construction to those used upon small motors. The diagrammatic illustration of the principle of operation is given in Fig. 11.

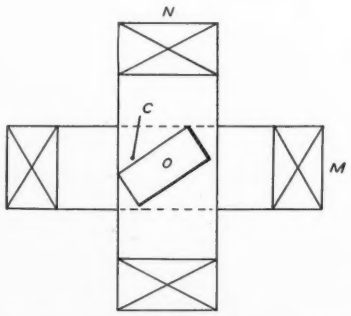


FIG. 12. RELATIVE POSITION OF A POWERFACTOR METER COILS

A stationary coil F has suspended within it a coil A, free to move about an axis in the plane of both coils and including a diameter of each. If an alternating current be passed through both coils, F and A, A will take up a position with its plane parallel to the plane on F. If now the currents in A and F be reversed with respect to each other, coil A will take up a position 180 deg. from its former position. Reversal of the relative direction of current in A and F is equivalent to changing their phase relation by 180 deg. and therefore in practice this change of 180 deg. in phase relation is followed by a corresponding change of 180 deg. in their mechanical relation. If instead of reversing the relative direction of current in A and F the changes between them be made gradually and without disturbing the current strength in either coil, it is evident that when the phase difference between A and F reaches 90 deg. the force between F and A will become zero, and the coil A will remain in the position in which it is placed.

A coil B, which is attached rigidly to coil A, with its plane 90 deg. from that of the coil A, and the axis of A passing through the diameter common to both A and B carries current in phase with coil A and thus makes the position of the movable part positive with respect to coil F no matter what the phase relation may be.

As commercially constructed coil F consists of a small laminated iron field, provided with a winding whose terminals are connected to binding posts. The coils A and B are windings practically 90 deg. apart on a laminated iron armature, pivoted between the poles of the field. These 2 windings are connected to the other generator, one of them through a non-inductive resistance, and the other through an inductive resistance. A light aluminum hand, attached to the armature shaft, marks the position assumed by the armature, and by its direction of motion indicates whether the incoming machine is running too slow or too fast.

In Fig. 12 is illustrated diagrammatically the relation between coils on a 2-phase power-factor meter. N and M are 2 coils arranged at right angles to each other. Through the coil N passes a current which is in phase with the current of one phase from the circuit to be measured. Through the coil M passes a current which is 90 deg. out of phase with that in coil N. With a 2-phase circuit the coil N would be connected to one phase and the coil M to the other. In the 3-phase circuit 3 coils would be used, one to be connected to each phase.

As the current in coil N will be maximum when that in coil M is zero, and vice versa, the field produced by these 2 coils will rotate with a speed which is dependent upon the frequency of the circuit in which they are connected. A small coil C is pivoted so that it can rotate and thus bring its axis in a line with coil N or M. Through this small coil passes a current in phase with the voltage of one phase of the circuit which is to be measured.

The movable coil C will thus shift around to a position which corresponds to the phase angle between the currents in the coils N and C. Therefore, if a pointer were attached to this coil and made to move over a scale graduated in degrees, it would show the difference in degrees between the phases of these 2 currents.

As actually constructed in this instrument the coil C is replaced by a movable piece of iron, this iron being magnetized by a stationary coil in a manner similar to the field in a revolving field induction type generator. This movable piece of iron performs the same function as a movable coil, and obviates the necessity of carrying current to a movable coil, thus simplifying the construction of the instrument. The scale is graduated to read the cosine of the phase angle between the voltage and current, which is the power factor of the circuit.

GENERATORS FOR ISOLATED ELECTRIC POWER PLANTS

IN THE layout of an isolated electric power plant the first essential point is to know just what class of service is to be performed and the amount of distribution which will be required, then the choice of the electrical system to be employed can be made.

Direct-Current Systems

When it is desired to generate electrical power for incandescent lights, mercury-vapor lamps, electroplating, charging storage batteries, running small motors, and the like, a direct-current, 2-wire, 125-volt system is used almost exclusively. The 3-wire direct-current, 150 to 125-volt system is of advantage where current is distributed to buildings a short distance away as it makes possible considerable saving in the cost of copper and permits the use of motors of a larger size. Direct current of higher voltages presents but few advantages to the isolated plant and its employment is seldom justified.

Alternating Current Systems

Alternating-current systems employed in isolated power plants are generally single or 2-phase, although 3-phase current may be employed to advantage under certain conditions. The frequency almost universally adopted in this class of work is 60 cycles per second and apparatus of this class is standard with all manufacturers.

The matter of voltage depends upon the distance to which it is necessary to transmit the power. Service lines for lighting are almost invariably 125-volt for the 2-wire system, or 250-volt for the 3-wire Edison sys-

tem, and the e. m. f. at the generators is 125, 250, 1,100 or 2,200 volts. This may be converted into any desired voltage for a particular purpose by means of transformers of the proper ratio.

Single-phase systems are frequently employed where the load is nearly all lights, with the addition of a few small motors. The 2-phase system seems to be the most popular for this class of work, as it adapts itself readily to circuits for lighting of all kinds, except the mercury-vapor lamp, and on the power circuits for almost any service the efficiency is high. In places where there is danger of electric sparks igniting gases or other combustibles, an alternating-current circuit for power is essential.

Circuits that transmit any great distance are usually 3-phase, but this is not the case with isolated plants except where they are really substations, in which case, by the use of 2 transformers, the system may be changed to 2-phase of any desired voltage for use about the plant. The 3-phase system has its advantages where a power circuit only is employed, but

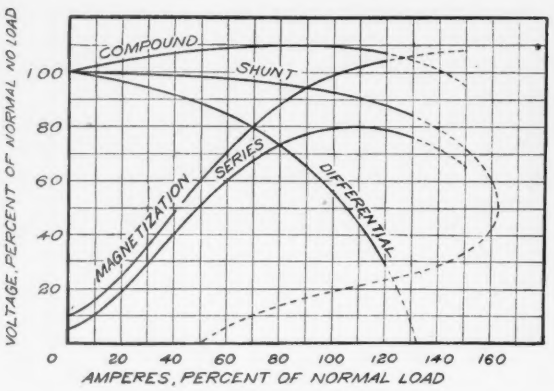


FIG. 1. CHARACTERISTIC CURVES OF DIRECT CURRENT GENERATORS

for general service, the complicated system of wiring and the difficulty of keeping the phases balanced have limited its employment in isolated power plants.

Selection of Generators

The characteristics of an average direct-current generator such as are on the market are as shown in Fig. 1. These types consist of shunt, series and compound wound generators. The curve of magnetization is plotted between terminal voltage and field current and shows the magnetic intensity at which the iron is worked and the small increase above normal voltage which is possible in standard machines.

The load characteristic of the shunt machine, plotted between terminal voltage and load current, shows that the voltage falls in almost direct proportion to the load down to about 70 per cent rated load, when the decrease becomes more rapid, and finally a maximum current is reached beyond which both current and voltage decrease with a decrease in external resistance. From an examination of this curve, it is evident that the machine is capable of carrying a very large overcurrent but that a short circuit will kill the field and do no great harm if it has shunt winding only.

The voltage curve for the compound-wound generator as shown rises to a maximum at approximately full load, when it begins to drop. A short circuit on this machine will, therefore, do a great deal of damage if allowed to continue for any length of time.

The differentially compound-wound generator is one in which the series field is wound in opposition to the shunt field coils. The characteristic, therefore, of this generator is a more drooping curve than the shunt-wound machine and at its maximum current reaches zero potential.

The series generator characteristic rises from almost zero voltage at no load to its maximum voltage at full load and then drops again. In the figure it is plotted relative to the magnetization curve instead of to the per cent scale of no-load voltage as are the others.

From an examination of these curves, it will be seen that the shunt-wound generator is most suitable for operating in parallel with other machines of the same type. For by its inherent characteristic, the voltage drops as the load increases, and in that way the load is evened up between the generators.

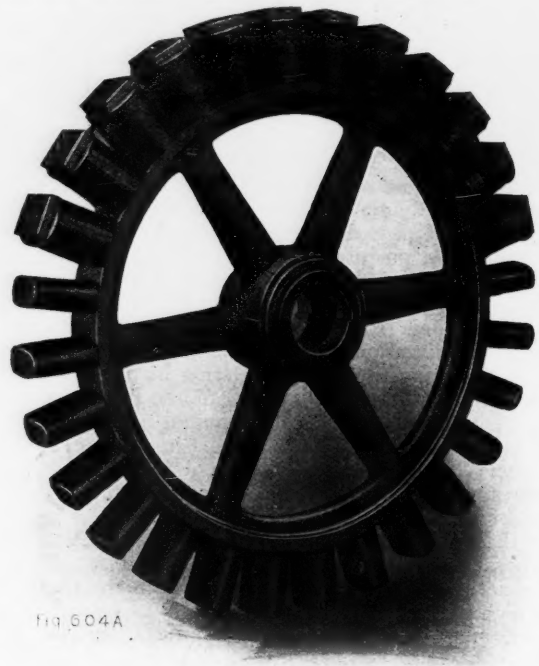


FIG. 2. REVOLVING FIELD OF CROCKER WHEELER GENERATOR SHOWING METHOD OF SECURING FIELD COILS AND CONNECTIONS

With series and compound-wound generators, however, the opposite effect is produced by an increase in load. To run these machines successfully in parallel it is necessary to connect their series fields in parallel by a connection of very low resistance so that if the load on one machine increases from any cause, a part of the additional current will flow through the series coils of the other machines and raise their voltage correspondingly. This connection of the machine sides of the series coils is called the equalizer, and it is evident that the less its resistance, the more closely will the machines divide the load.

It will be seen from this discussion that for direct current the shunt-wound, or compound-wound generators with the equalizer connection are the ones best adapted for isolated lighting plants, and, as a matter of fact, they are almost universally used for this purpose.

Alternating-current generators may be divided into

3 distinct types according to their mechanical construction: revolving armature, revolving field, and inductor alternators.

The revolving armature type may be used for all general purposes; it is comparatively cheap and can be compounded without complication, which is not the case with either the revolving field or the inductor type. It also operates with a higher efficiency than either of the other 2 types. This type of machine, however, is limited to moderate voltage and speed, due to the fact that with low voltage a high current is necessary and considerable difficulty is experienced in carrying heavy current through sliding contacts. On the other hand with a high potential it is difficult to insulate moving wires. This same difficulty is met with wherever a generator is run at high speed.

The revolving field type of alternators is suitable for either high or low voltage as the armature wires are stationary and can be insulated to a high degree. A heavy current may be passed through these coils without difficulty, as there are no sliding contacts, the only current which has to pass through sliding contacts being that necessary to excite the field.

The inductor type of alternator has the advantage of being constructed with no moving wires and no collecting rings or brushes. The attendance and maintenance cost of this machine is low, but for close regulation the size of the machine must be increased and the cost necessarily goes up.

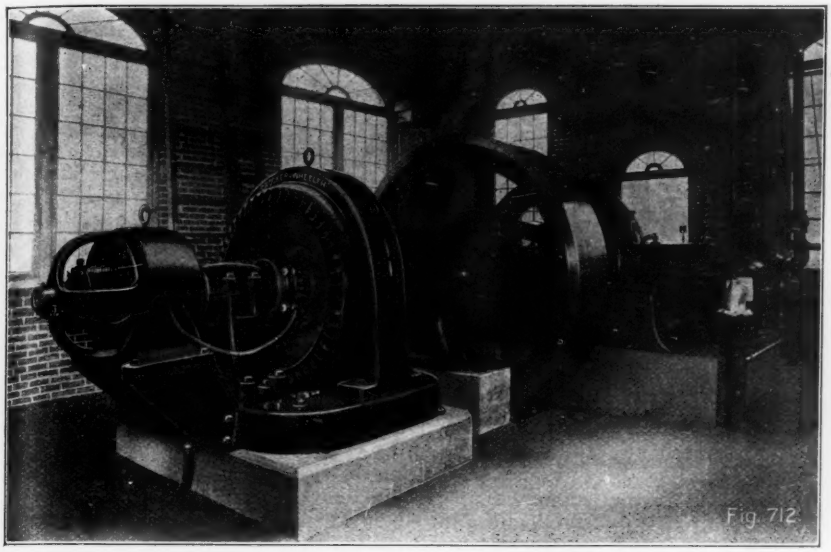


FIG. 4. CROCKER-WHEELER GENERATOR DIRECT CONNECTED TO A GAS ENGINE

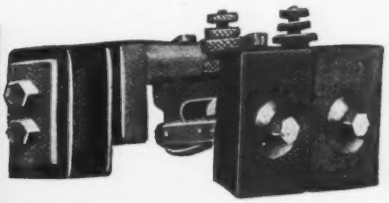


FIG. 6. TRIUMPH HINGE RADIAL BRUSH HOLDER

FIG. 7. GENERAL ELECTRIC C. S. BRUSH HOLDER

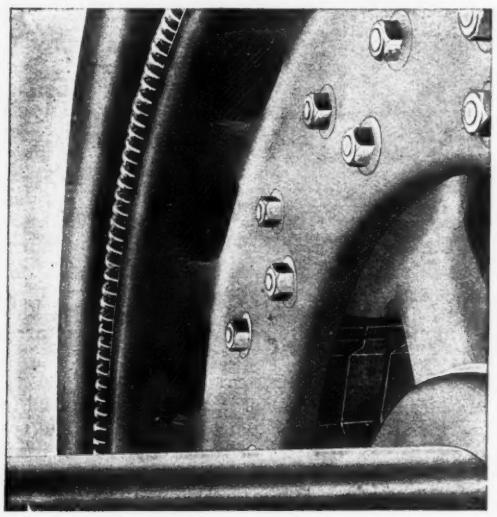


FIG. 5. DETAIL OF FORT WAYNE ARMATURE SHOWING VENTILATING SPACES

The regulation of alternating-current generators is now generally understood to be the per cent rise in voltage due to taking off full noninductive load without changing the speed or excitation, and, in well designed generators, should not exceed 10 per cent.

Relative Cost of Generators

The principal factor in the cost of generators is the speed at which they are to be operated considering machines of equal kilowatts output. The cost of direct-current generators is necessarily higher than that of alternating-current machines, owing to the expense of the commutator, which is a complicated and rather delicately constructed piece of apparatus; and these machines must also run at a lower speed than the alternating-current generators in order to secure good commutation.

Belted type generators are able to run faster than those which are direct connected to the prime mover, the speed of the former being limited only by the machine itself, while with the generator direct connected to a steam engine or water wheel, the limit of speed is governed by the prime mover. Belted machines are, therefore, generally cheaper than direct-connected machines, owing to the fact that they may be made smaller for a given output and voltage.

There is a limit, however, to the size of belted machines; large generators must be direct connected, as the belted machine would require too much space, the cost for belts and maintenance is too high, friction loss, and the noise and danger due to moving belts are factors to be considered.

The cost of generators is also affected by the voltage delivered at the terminals. This is due to the fact that the high-voltage machine requires great care and expense in insulating the armatures. Generators with high efficiency and close regulation require a liberal use of iron and copper and are, therefore, more expensive than those of moderate efficiency and regulation. To increase the frequency of an alternator increases the number of poles and also the number of

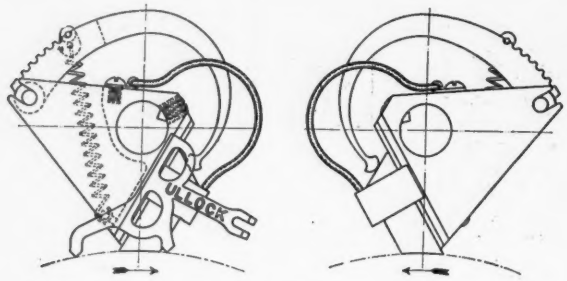


FIG. 8. ALLIS-CHALMERS BRUSHHOLDER

armature coils and will make the cost of the generator more. For the same voltage and kilowatt output the 2-phase generator is cheaper than the single-phase, because the 2-phase machine requires less copper and no more field or armature iron.

Generator Details

The operation of a generator depends largely upon the system of ventilation and this item should not be

FIG. 9. DETAILS OF CROCKER-WHEELER A. C. GENERATOR FIELD

overlooked in the choice of apparatus. Nearly all generators are constructed with air ducts through the laminated cores of the armature which permit the cool air to flow from the shaft through the iron core and come in contact with the coils of the armature at many points, thus keeping the temperature of the coils and iron low. In some cases this circulation of air is aided by fans on the shaft or by vanes attached to the spider. Another feature in the design of an armature which aids in keeping down the temperature is the open winding at the end of the armature which allows the heat from the center of the armature to be conducted to the ends by the copper coils and there rapidly carried off by a strong draft of air.

The points aimed at in the design of a brush-holder are to secure one which will run sparkless, noiseless and cool. Brushes to run sparkless must feed in such a way that all parts of the brush bear upon the commutator evenly throughout the life of the brush. The accompanying illustrations show how this is accomplished by several of the manufacturers. In order to run noiseless, brushes must be so securely fastened that there can be no vibration or the angle which the brush makes with the commutator must be such as to give no chattering while the armature is in motion.

To run cool, brushes must be of sufficient cross-sectional area to carry the full current, the density ranging from 30 to 40 amperes per square inch, and good electrical contact between the brush and the brush-holder is essential; flexible copper shunts are

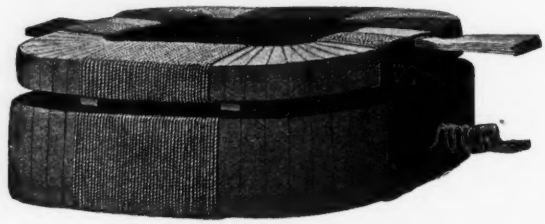


FIG. 10. SHUNT AND SERIES FIELD COILS OF TRIUMPH GENERATOR

employed in many cases for this purpose. Proper pressure of the brush on the commutator should be maintained, as an extra pressure will give undue friction and too light pressure gives sparking. Good practice allows between 1.25 ad 1.75 lb. per square inch of area.

The field windings on a generator vary largely with the size of the unit. Coils are always form wound, in the small sizes being of wire, and in the larger sizes of copper strip wound edgewise. Ventilating space should be allowed on all sides of the coils and thorough insulation between the windings and the core is necessary. Edgewise-wound coils conduct heat more

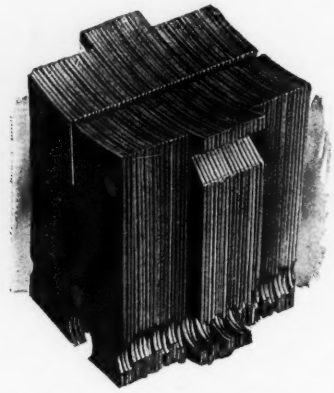


FIG. 11. LAMINATED POLE PIECE BEFORE BEING CAST INTO FRAME OF A FORT WAYNE GENERATOR

readily from the center of the coils to the outside, and are recommended in all cases where the field current is high.

Stationary-field generators of all kinds have pole pieces of laminated iron, which are either bolted to the frame or cast into it. When the field is of the revolving type, the pole pieces are of laminated iron frequently dovetailed into the yoke or built up forming also part of the rim. The main part of the pole pieces is made with round, oblong, rectangular, or cruciform cross section; the pole faces, however, are always rectangular and the tips of such a design that they operate with a high magnetic density and thus produce the least amount of distortion of the magnetic field.

Installation of Generators

Usually not much choice is offered in the location of an isolated lighting plant, for the load is generally

concentrated and the generator placed where other conditions are most favorable. Generators should be located where there is the least danger of fire and should never be in the same compartment with high-tension oil transformers. A dry place should always be provided, as damp insulation is never perfect. For most efficient operation, the generator should, at all times, be kept cool, as an increase in temperature increases the loss due to copper and iron. Another important consideration in the location is to keep it entirely free from acid fumes of all kinds.

Foundations

These are required only for the heavier machines. For them the generator foundation should be on solid ground or rock and where the ground is soft, piling should be driven down to insure smooth running without vibration. Stone, when used should be large, well imbedded and laid in cement mortar. Where concrete is employed, it should not be weaker than 1 part cement, 3 parts of coarse sand and 6 parts of rubble.

For large generators, before the foundation is made a template representing the outer edge of the base of the generator should be made, with holes to receive the bolts in their proper place. The template is then set with the anchor bolts hanging by the nuts and the tops of the bolts projecting above the floor line. A box or pipe should be placed around the bolts down to the anchor plates to protect them from dirt and mortar, these boxes being of a size to allow for slight lateral adjustment, and if the lower ends of the bolts are screwed through the nut on the anchor plate a short distance it will allow for adjustment in the length of the bolts.

The foundation is then built and when set the generator is put into position with a bolt through each hole and the machine lined up. To level up a generator iron wedges at 3 different points are used and the generator base or rails raised level and even with the floor. When the machine is properly leveled, wooden wedges should be inserted near each bolt hole, and the bolts drawn tight enough to insure against any derangement of the level or alignment. Cement is then poured into and around the base and allowed to set.

Leads.

The leads running from the generator to the switchboard should be enclosed in iron or tile conduit and are usually run beneath the floor. Overhead cables may be used for connecting the generator to the switchboard where it is impossible to install them in conduit, but modern power-plant practice does not favor this method. The leads are connected directly to the bus bars except when the machines are to be operated in parallel in which case knife-switches are employed between the bus bars and the generators. Where belted type generators are used, allowance should be made at the generator end of the conduit for shifting the machine to adjust the tension of the belt.

If the field of the generator is opened suddenly, the kick due to the inductance of the field is sufficiently strong to break down the insulation on the windings of the field, and for this reason some means must be provided for a discharge, which is usually done by employing a switch with a discharge clip and resistance.

Starting Generators

When the generator has been assembled and all connections have been made, before the machine is turned over, care should be taken to see that all switches are opened and oil put in the bearings. The brushes should be fitted to the commutator or collecting rings properly, all dust, particularly copper, carbon or iron filings, should be blown out of the machine, and all pieces of iron such as wrenches, bolts, nuts, etc., be removed from the machine, as the magnetism may draw them into the air gap and cause considerable damage to the armature.

When these precautions have been taken, the machine may be started slowly and close observation should be made at all times for peculiarities, such as clicking noises, due to loose pulleys, striking of parts, etc. The collecting rings or commutator should run true and free end play of the shaft is necessary for good bearing and commutation. The bearings should be watched closely to see that they do not heat, and the oiling rings kept running so that the oil supply does not fail. The generator may then be gradually brought up to the rated speed and, after running long enough to be sure that all is right, normal voltage may be induced by cutting out resistance from the field circuit.

If the generator shows any evidence of having become moist during shipment or storage, it should be dried out before bringing to voltage, as the insulation may be so damaged as to break down should even normal voltage be placed upon it. This process is done by short circuiting the generator with circuit through an ammeter and running it at such a speed and field strength that the temperature of the armature winding is maintained at about 158 deg. F. for a period of 24 hr. or more. The insulation of generators should be not less than 1 megohm (or 1,000,000 ohms) per 1,000 volts of rated capacity.

Before any load is put on a composite-wound, alternating-current generator, the commutator brushes should be lowered as an abnormal voltage is apt to occur when these brushes are raised and a heavy current is flowing in the armature.

The brushes on all commutator generators should be shifted to a sparkless position when carrying a load, as when at that position the commutator runs coolest and the best efficiency of the generator is obtained.

Care

In the operation of generators the attendant should be on the alert for peculiar conditions and noises. All parts of the machine should run reasonably cool for efficient operation. Sparkless commutation in direct-current machines and collecting rings is a necessary condition for best operation. Vaseline applied with a cloth on the end of a stick makes an excellent lubricant for the commutator, another method of lubrication is to boil the brushes in vaseline. If the commutator becomes rough, pitted, etc., it may be polished with No. 00 sandpaper, but if too badly pitted or out of true it should be turned down on a lathe, or in place.

The bearings should be given especial attention to keep them clean and free from dirt and grit, and the oil in the housings should be removed every 6 months and run through a filter before being used again.

In case the feeder fuse blows or a breaker opens the switch corresponding to that line should be opened and the fuse replaced or the circuit breaker closed. The switch is then closed, and if the same thing occurs again, look for trouble. In case of a short circuit or arc near the machine, throw in field resistance to lower the voltage. Where that is not sufficient to stop the arc open the field switch or shut down.

In shutting down reduce the field current by throwing in resistance, throw off the load by opening the circuit breaker or generator switch, if one is used, open

the exciter field, if an alternator, shut down the driving engine and wipe off all oil and dirt, then clean the machine for the next run.

DIRECT CURRENT GENERATORS, THEIR CONNECTIONS—EFFECT OF RESIDUAL MAGNETISM

BY J. C. KAHL AND L. A. COLE

DIRECT-CURRENT generators are divided into 3 general classes —series wound, shunt wound and compound wound. In Fig. 1 is shown a series wound generator, and by tracing out its connections by aid of the arrows it will be found that the entire armature current flows through the field coils.

Series Winding

With this type of generator the magnetizing force or rather the strength of the magnetic field in which

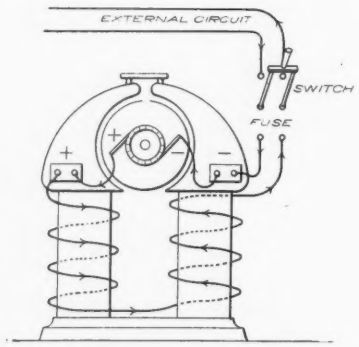


FIG. 1. WIRING FOR A SERIES GENERATOR

the armature rotates will vary with the quantity of current which the generator should happen to be carrying to meet the demands of the external circuit. Therefore when the armature is operating at a constant speed its electromotive force varies as the quantity of current varies, though not necessarily in

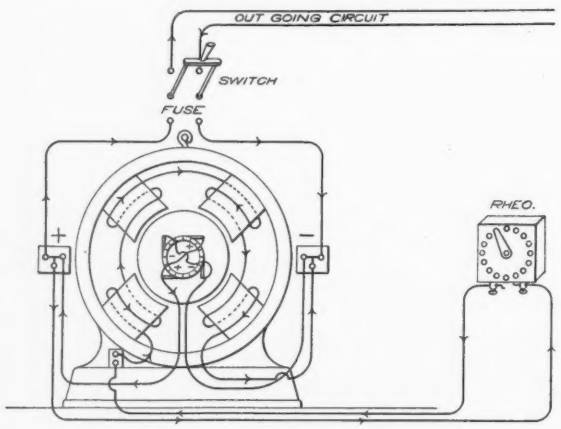


FIG. 2. SHUNT WOUND GENERATOR

proportion. In fact this is not usually desirable since most applications of direct current require that either voltage or current alone be maintained approximately constant.

To realize either condition in a series wound generator it is necessary to adopt some method of regulation whereby the electromotive force may be varied to suit the requirements of the service. This is usually accomplished in constant current dynamos by shifting the brushes from the neutral point, which entails special construction and precautions against sparking.

Shunt Wound

Figure 2 shows a shunt-wound dynamo, and by tracing out the field connections it will be found that

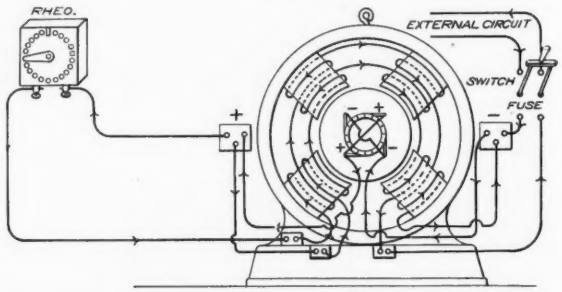


FIG. 3. FIELD WINDING OF COMPOUND GENERATOR

the field coils are connected across the terminals of the generator and in parallel with the external circuit. The magnetizing current thus being practically independent of the external circuit receiving at all times the full difference of potential between the brushes. The changes of quantity of current in the external circuit do not affect the magnetizing force of the field magnets except as they may change the potential between the brushes.

The strength of the current flowing through the field magnet coils is governed within certain limits, depending upon the demand of the external circuit by

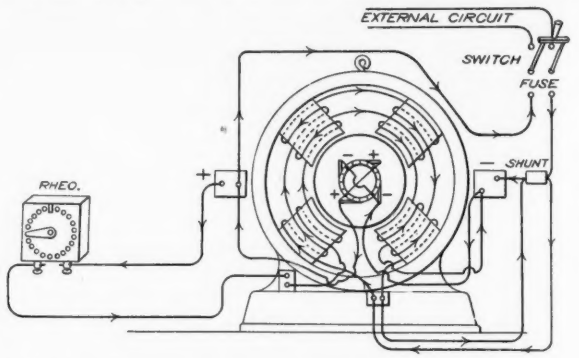


FIG. 4. SHUNTED COMPOUND GENERATOR FIELD WINDING

the use of the rheostat shown, with its resistance connected in the path of the field circuit.

Compounding

To maintain a constant potential between the brushes under varying conditions of load, assuming that a constant speed is maintained, the magnetizing force of the field winding must be increased as the current increases, so as to increase the generated voltage just enough to make up for the additional losses incurred.

This is accomplished by providing an extra winding connected in series with the armature similar to the winding of a series-wound generator. This is

known as compound winding and Fig. 3 gives a view of such a generator.

Each field magnet is provided with 2 coils; one set of these coils is connected in parallel with the external circuit and the other is connected in series with the armature and external circuit, the one set being the shunt coils while the other set are the series coils. Thus this compound-wound generator is a combination of both the types shown in Figs. 1 and 2.

The shunt winding furnishes a constant magnetizing force and the series winding an additional magnetizing force which is proportional to the current output of the generator. The series winding is so proportioned that as the current increases it produces the proper increase in the electromotive force to make up for the dropping off of voltage that would otherwise occur by reason of resistance losses.

For certain work a little more than this amount is provided so that the difference of potential between

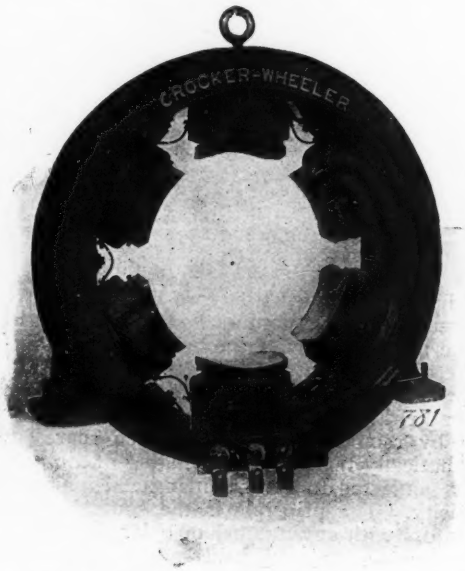


FIG. 5. COMPLETE FIELD FRAME SHOWING SHUNTED COMPOUND WINDING

the brushes rises slightly as the current output increases. Dynamos so wound are known as overcompounded.

Long and Short Shunt

There are 2 ways in which the shunt winding of a compound-wound generator may be connected, the long shunt and the short shunt. In the long shunt the entire current of the armature first passes through the series coils, then a small current is taken from the lead and passed through the shunt coils; while in the short shunt the shunt winding connections are made just the same as in the generator of Fig. 2.

Compound Shunt

In Fig. 4 we have a compound-wound generator in which the connections to the compound winding are made to a resistance shunt which is inserted in one of the generator leads; the shunt being of such capacity as to furnish the degree of compounding desired. This method of compounding is desirable in large generators where it would be inconvenient to wind the series coils of conductors sufficiently large to carry the entire armature output of current.

In the types of dynamos referred to, the iron of the field magnets contains a certain amount of residual magnetism after being magnetized, consequently a small electromotive force is generated in the armature winding when the armature is rotated with the external or work circuit open; this is utilized to start the current in the field winding.

Building Up Voltage

In the case of a shunt-wound generator, when the machine is started the small residual magnetism sends a small current through the field coils producing a

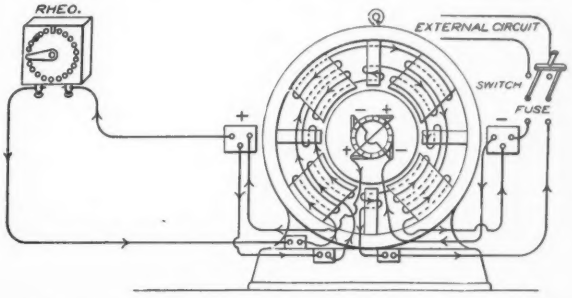


FIG. 6. FIELD WINDING FOR INTER POLE GENERATOR

small magnetizing force; this magnetizing force adds to the residual magnetism, thereby increasing the electromotive force, which increases the current in the field magnet coils, thus still further increasing the electromotive force, this continuing until the generator reaches its normal voltage. If the external circuit is closed when the generator is started, only a part of the feeble current produced by the residual magnetism will flow through the field coils and the field will build up more slowly.

A compound-wound generator may be started with the external circuit closed or open, since the generator has both shunt and series field coils.

Interpole Construction

In Fig. 6 we have what is known as an interpole generator, which is an improved compounded type.

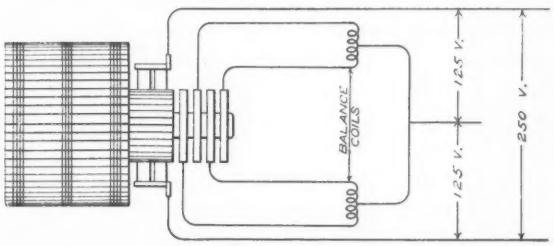


FIG. 7. 3-WIRE DIRECT CURRENT GENERATOR

The construction is essentially the same as an ordinary compound-wound generator with the addition of the small intermediate magnet as shown, the magnetizing coils of these poles are connected in series with the armature and the regular series field coils and their strength is, therefore, proportional to the load the generator is carrying. To explain fully the function of the extra field poles which are to insure sparkless commutation at all loads, it will be necessary to consider the effect of armature reaction.

Armature Reaction

In all dynamos the magnetizing effect of the armature winding opposes that of the field winding and

thus distorts the magnetic field under each pole face, which shifts the neutral point necessitating a shifting of the brushes to obtain sparkless commutation. The shifting of the brushes is necessary to bring the coils short circuited by the brushes under the influence of the distorted magnetic field so that it may generate in them an electromotive force sufficient to reverse the current in the coils to the direction in which it should flow when the coils leave the brushes.

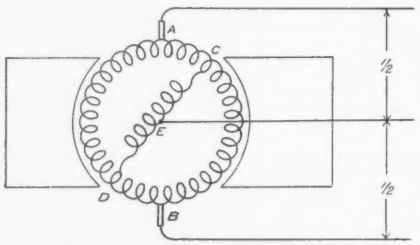


FIG. 8. ARMATURE DIAGRAM OF 3-WIRE GENERATOR

The purpose of the intermediate poles is to maintain a fixed commutating field so that no adjustment of brushes is necessary.

One type of dynamo known as the Thompson-Ryan compensated dynamo, which is of special construction, maintains sparkless commutation from no load to full load without shifting the brushes. It is of the multipolar type, and inside the ring of field magnet poles on which are mounted the usual shunt field coils, is a laminated iron ring slotted somewhat like the stator of an induction motor. In the slots of this ring are wound the coils which correspond to the series field coils of the ordinary compound-wound generator.

These coils are parallel to the armature coils, but the current flows through them in the opposite direction to that in the armature winding, the result being that these series coils set up a magnetic field exactly opposite to that set up by the armature winding, and as they are connected in series with the armature the current flowing in them is the same as that in the armature and the 2 fields neutralize each other.

The result of this is that the magnetic field, due to the shunt field winding remains stationary and gives a fixed point of commutation. A portion of the series winding embraces lugs in the laminated ring midway between the main field magnet poles and produces a commutating field in the same way as the intermediate poles in the generator, Fig. 6.

Three-Wire Dynamo

Figure 7 is a diagrammatic sketch of the connections and the armature of a Westinghouse double-voltage or 3-wire, direct-current generator, these connections being shown diagrammatically because of their simplicity in this form.

This type of generator is designed to take the place of the 2 generators ordinarily employed to operate the 3-wire system which originally consisted of 2 generators connected in series, each delivering current at the voltage of the lamps plus the line drop, and a neutral wire leading out from the connection between the 2 machines, in which case both generators must always be in service regardless of the load on them.

Practically all of the advantages of the 3-wire system are retained in the double-voltage or 3-wire generator, and there are additional advantages due to using a single generator instead of 2 of half its capacity.

The double-voltage or 3-wire generator differs from the standard single-voltage, 2-wire, direct-current generator only by the addition of leads from the armature winding which are connected to collector rings mounted on the armature shaft as shown in Fig. 7.

This arrangement is exactly similar to that employed for the alternating current side of the armature of a double-current generator. The connections from the armature to the collector rings may be the same as a single-phase, 2-phase or 3-phase generator, but the 2-phase connection is generally used.

A pair of balancing coils are connected across the brushes of the collector rings as shown in Fig. 7. These balancing coils consist each of a single winding

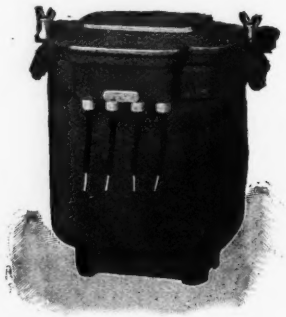


FIG. 10. COMPENSATOR MADE BY THE GENERAL ELECTRIC CO.

encircling a laminated iron core like that of the shell type transformer and are mounted in an oil-filled case.

The middle points of the balancing coils are interconnected, and from this connection the neutral of the 3-wire is led out. The voltage between the neutral wire and either of the main wires may easily be understood by reference to Fig. 8, which represents diagrammatically the armature winding of a bipolar generator connected to one balancing coil for the sake of simplicity. The principle is the same in multipolar generators with any number of balancing coils.

The direct current brushes are represented by the blocks at the points A and B. The balancing coil is permanently and symmetrically connected to the armature winding and the neutral wire is connected to the point E exactly in the middle of the balancing coil. The armature winding and connections being symmetrical, it is evident that when the terminals of the balancing coil are directly under the brushes, that is, when point D is under the brush A, and the point C is under brush B, the coil is subjected to the full voltage of the generator and the potential between the mid-point E and the brush A and that between E and B is one-half that between A and B. Correspondingly, when the armature has rotated 90 deg. so that points C and D lie directly under the pole centers the coil is subjected to no difference of potential and the voltages between E and A and E and B are equal respectively to the voltages between D and A and C and B.

But since the winding is symmetrical, the voltage between A and D is equal to that between B and C. Consequently the voltage between E and A is equal to that between E and B. This holds good in all positions of the armature. The voltage between E and A being the resultant of half the voltage of the coil and that of the armature winding between A and one terminal of the coil. Since the voltages between A and E and B and E are always equal it follows that E is the neutral point of the system and may so be used.

STORAGE BATTERIES

ECONOMICAL operation demanded in isolated electric lighting plants where the power consumed does not warrant the expense of running the generator the full 24 hr. of the day, has been made possible largely through the perfection of storage batteries. These are arranged to be charged while the load on the machine is low and during that period of the day when the load is lightest, the generator may be shut down and the load carried by the batteries. As an auxiliary in a small lighting plant, the storage

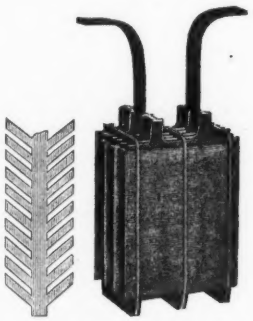


FIG. 1. GROOVED PLANTE PLATES MADE BY THE AMERICAN BATTERY CO.

battery is very convenient at times when it is found necessary to repair the generators.

Plate Material

The material from which storage battery plates are made depends largely upon the use to which they are to be adapted. Batteries are now being manufactured with plates made of iron and nickel, lead and

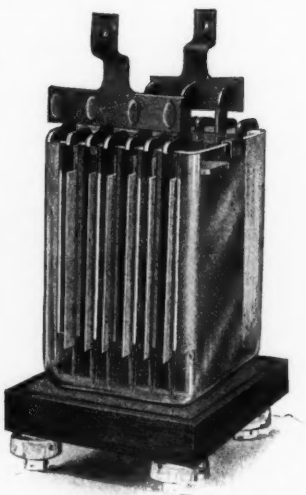


FIG. 2. GOULD GLASS JAR TYPE WITH SAND TRAY

zinc, and lead and lead. For engineering purposes, however, the lead and lead cell is used almost exclusively.

In batteries of this class the negative plates are made of sponge lead, which has a light gray color and is very soft. The positive plates are of peroxide of lead, being dull chocolate in color and hard in texture.

The electrolyte almost universally adopted for storage batteries is dilute sulphuric acid, made from pure sulphur and not from the pyrites. This acid may be secured direct from the manufacturers of the storage batteries, diluted to the proper density or the engineer may mix it by pouring a sufficient amount of concentrated sulphuric acid into pure distilled water until the specific gravity of the liquid is shown by the hydrometer to be 1.17, which is the proper density of the electrolyte when starting to charge the battery.

After the sulphuric acid is diluted properly, it is not put into the cells until everything is in readiness to begin the charge. Before the generator switch is thrown in, the rheostat resistance is cut into the circuit so as to give as nearly as possible the proper voltage for charging the battery.

When a battery has been charged for the first time, the discharge should be moderate, that is, carried only until the density of the electrolyte is about 1.2. The

FIG. 3. LEAD LINED WOODEN TANK OF GENERAL STORAGE BATTERY CO.

charging of the battery should always be thorough and continued until the specific gravity is about 1.24. This method of moderate discharge and thorough charge should be carried on for several cycles before the battery is put into full operation.

In order to prevent sulphating, the battery should never be discharged to the point where the density of the electrolyte falls below 1.8. Continued use of a battery will gradually increase the density of the electrolyte by decomposing the water, and the liquid can be brought down to the proper density by diluting with pure distilled water.

Chemical Change

When fully charged, the plates are pure lead for the negative and peroxide of lead for the positive. These have formed upon their surfaces during their normal discharge, a very slight coating of lead sulphate, with the liberation of oxygen gas from the positive and hydrogen gas from the negative plates. Upon recharging, the sulphate upon the plates combines with the acid and disassociated gases, with the result that the positive plate again becomes peroxide of lead, and the negative plate, pure sponge lead.

Sulphating of the injurious kind differs from the normal sulphating of charge and discharge, in that it

is almost irreducible, causes shedding of active material, buckling, loss of capacity, increase of internal resistance with consequent reduction of efficiency and increase of temperature with passage of current.

There is considerable variety in the opinions of investigators as to the exact chemical composition of the sulphate which forms on the storage battery plates, but for all practical purposes, the injurious sulphate may be considered as the result of an overdischarge.

Types of Plates

Storage battery plates may, in general, be divided into 2 classes, Plante and Faure, the difference being

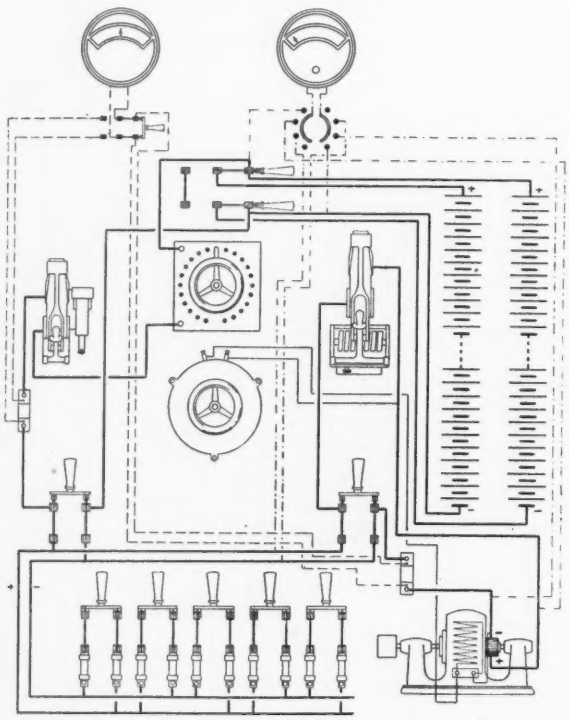


FIG. 5. DIAGRAM FOR PARALLEL-CHARGE, SERIES-DISCHARGE SYSTEM

principally in the method of forming them. In the Plante type, the lead is chemically attacked and finally converted into lead peroxide, probably after it has gone through several intermediate changes. The plates are all formed as positive plates first and then all that are intended for negatives are reversed, the peroxide being changed into sponge lead.

In order to make this type of plate more efficient, and its formation more rapid, the surfaces are finely subdivided, the following methods being those most common: scoring, grooving, laminating, casting, pressing and by the use of a lead wool.

The Faure or pasted type is one which is formed by attaching the active material by some mechanical means to the grid proper. The active material first used for this purpose was red lead, which was reduced in a short time to lead peroxide when connected as the positive or anode, or to spongy metallic lead when connected as the cathode or negative, thus forming plates of the same chemical compound as in the Plante type. The materials used at the present time by the manufacturers for making this paste are very largely a secret with them, but in general they consist of pulverized lead or lead oxide mixed with some liquid to make a paste.

The Faure plates are usually lighter and of higher capacity than the Plante, but have a tendency to shed the material from the grid, thus making the battery useless. Many ways have been tried for mechanically holding the active material to the grid, the general method being by a special design in the shape of the grid. Some of these designs are solid perforated sheets or lattice work; corrugated and solid recess plates not perforated; ribbed plates with projecting portions; grid cast around active material; lead envelopes; triangular troughs as horizontal ribs.

Tanks

The usual form of tank used for storage batteries is of glass, which is very convenient, for the condition and color of the plates may be seen without removing them. Lead lined wooden tanks are used extensively for batteries of large capacity. They are not so easily broken or apt to be cracked in case of a frost as the glass tanks.

System of Charge and Discharge

There are 3 systems of charging and discharging storage batteries now in general use; these are known as, first, normal voltage charge with resistance regulation; second, high voltage charge with end cell discharge; and third, booster charge with end cell discharge. In the arrangement for normal voltage charge with resistance regulation, the battery of 60 cells, is divided into halves of 30 cells each, and the 2 halves are either charged separately or in parallel through a resistance. The object of this scheme is to permit the cells to be charged with the current from a 110-volt dynamo.

The objection to this arrangement is the loss of power in the charging rheostat, as it is necessary to reduce the voltage by the rheostat from 110 to 63 at the beginning, and to 79 at the end of the discharge. This loss, however, does not necessarily occur except when current is supplied to lamps during the period of charge. If no lamps are required at this time, it is possible to reduce the voltage of the generator to the value at which the series resistance can be cut entirely out of the circuit, the batteries being directly connected to the generator, and the charging current regulated by means of the generator field rheostat.

The voltage of the discharge is regulated by means of the same series resistance that is used in charging. The loss of power in this case is comparatively small, as the maximum voltage drop in the rheostat is never in excess of 12 volts with the 60 cell battery on the 110 volt system. This system is the least expensive to install and is the one generally used for small installations where low first cost, simplicity of construction and ease of operation are of more importance than economy. The parallel-charge. series-discharge system of regulation is shown in Fig. 5.

The high voltage charge with end cell discharge system is adapted to plants of small size, but is in general a more expensive arrangement than the first mentioned system, except where the size of the generator is fixed by the charging rate of the battery. The battery is charged in 1 series and requires a generator of 155 volts, but the generator ampere capacity required for this purpose is one-half of that required in the first system. The discharge voltage is controlled by cutting in or out end cells, and the additional installation cost due to the end cell wiring must be taken into consideration in comparing the 2 systems.

The third system, that of booster charge and end cell discharge, employs a motor-generator set to raise the voltage of the line to 155 for charging and controls the discharge voltage by end cells. It is the most satisfactory arrangement for plants of comparatively large size, where the generator has a current capacity considerably larger than the normal charging rate of the battery. Where the generator has a current capacity approximately the same as the normal charging rate, and can have its voltage increased to 155 volts, it is better to install the second system, but this is rather unusual.

THE STORAGE BATTERY FOR LIGHTING PLANTS

BY NORMAN S. CAMPBELL

A STORAGE battery does not store electricity as many believe, but it does store energy by converting the kinetic energy of the electric current into chemical potential energy, which may be reconverted into kinetic energy.

Storage batteries, or accumulators, depend upon chemical action for their operation. They consist of certain materials so arranged, that, when a current of electricity is passed through them, they undergo certain chemical changes due to the current; and, if

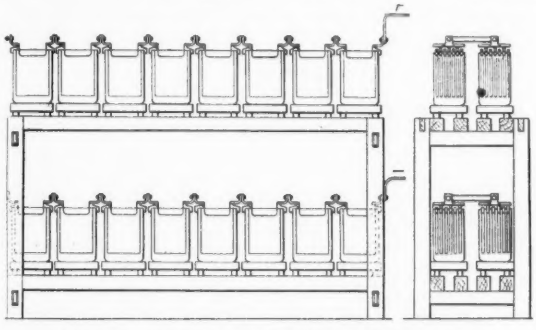


FIG. 1. RACK FOR STORAGE BATTERY CELLS

afterward connected to a closed circuit, will discharge a current nearly equal to the original charge.

Accumulators are coming into general use in plants furnishing current for lighting and power purposes—to help out on the peak load, and are charged when the output of the station is light, thus keeping the load on the generators near their full capacity, which condition gives greater economy in operation. They are also used to some extent in office buildings where electric elevators are installed serving to steady the load on the machine, and doing away with a separate unit for supplying current for elevators only. They can be charged at a somewhat higher rate than the discharging rate, so that the plant may be shut down part of the night, the battery supplying what little current is required during this time.

In battery installations for lighting purposes, the jars are usually made of glass, which permits the examination of the interior of each cell, at all times, so that any signs of buckling, or disintegration may be detected and attended to before it becomes serious.

Cells Needed.

The number of cells required for any installation depends on the e. m. f. desired, and may be determined by dividing the desired e. m. f. by the e. m. f. of each cell during discharge, which is about 1.9 volts. Extra cells called end cells should be provided, and so arranged that they may be cut in or out of the circuit as the case requires, so as to keep a constant voltage at the lamps.

Setting Up the Battery

The number of cells being determined, they should be placed on racks, and if the number is large, they

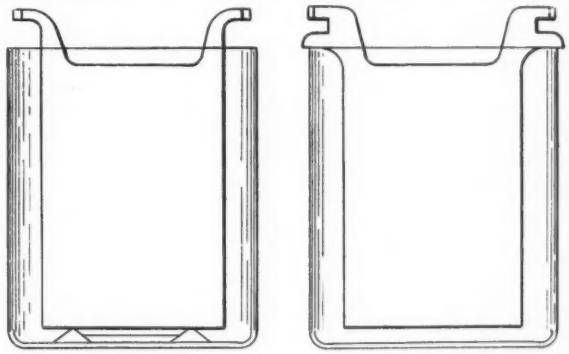


FIG. 2. PLATES SUPPORTED ON BOTTOM
FIG. 3. PLATES HANGING FROM JAR

may be placed in tiers, as shown in Fig. 1, plenty of room being left for inspection and replacing plates and electrolyte. After the racks are in position, wooden trays about 1 in. deep filled with fine sand should be set on glass or porcelain insulators on the racks, care being taken that none of the trays touch. The jars rest on the sand in the trays, the sand protecting them from vibration, and serving to lessen the liability to breakage. The racks should be made extra strong, as the weight of the cells when filled is considerable.

Having placed the jars in position, the plates should be put in them, so that the connecting strips will come in proper place for connecting the positive plates of one cell with the negative plates of the next, and so on; there is always 1 more negative plate than positive in each jar. The joints on the connecting strips should be scraped bright, and bolted together.

In some types of cell the plates rest on a support in the bottom of the jar, as in Fig. 2, and some rest

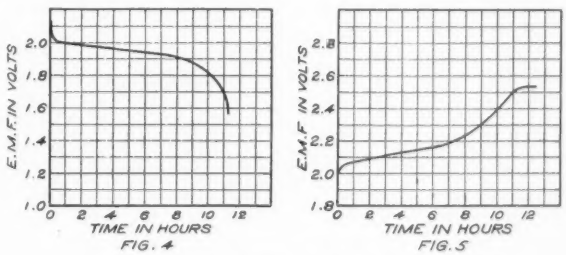


FIG. 4. FALL OF VOLTAGE ON DISCHARGE
FIG. 5. RISE OF VOLTAGE ON CHARGING

on the edges of the jar as in Fig. 3. Hard rubber, or wooden separators should be placed between the plates, after which the jars are ready to receive the electrolyte.

Electrolyte

The electrolyte should be prepared the day before it is put into the cells, as pouring the acid into the

water will cause the solution to become heated, and before it is placed in the cells, it should be the temperature of the surrounding air. In mixing the electrolyte, about 1 part acid to about 4 parts water are the proper proportions. It should show a specific gravity of about 1.17, and should be mixed in lead-lined or earthenware tanks. The solution should cover the plates in the jars about 0.5 in., and the cells should be charged at once.

Charging

The charging should continue without interruption for about 50 hr. The cells should be gasing freely at the end of charge and the specific gravity should show about 1.215. The positive plates at the end of charge should be a brown or deep red color, and the negative plates a slate gray.

It is necessary to have the source of charging current so arranged that it may be closely regulated in order to keep it at its proper value. In large installations this is accomplished by a separate dynamo, but in smaller plants a booster set is used. In this way the e. m. f. of the charging current may be adjusted without interfering with the e. m. f. of the lighting circuit. Whatever the source of charge, the battery should be charged at as near its normal rate as possible, as excessive charging will cause a rapid accumulation of sediment in the bottom of the cell and excessive evaporation of the electrolyte, and the life of the plates will be very much shortened.

Care of the Battery

A convenient cell should be selected as a pilot cell, and in it should be kept a hydrometer and a thermometer. The electrolyte in this cell should be kept at its proper height by replacing the evaporation every day with water. Hourly hydrometer readings should be taken during charge, as the state of charge can be properly determined in this way. Sulphuric acid is formed during charge, and decomposed during discharge, consequently the gravity will rise during charge and fall during discharge.

When first installed, the voltage at the end of charge will be from 2.55 to 2.65 volts per cell with a temperature of 70 deg. F., but as the battery grows older it will gradually fall in voltage to about 2.4. The effect of the change of temperature on the final charging voltage is that the voltage is lowered with an increase of temperature above 70 deg. F., and correspondingly increased with a lowering of temperature.

After the charge is completed and the current is cut off, the voltage per cell will fall rapidly to about 2.2, and when the discharge is started it will fall to about 2. The cells should not be discharged below 1.8 volts, as below this point sulphating is liable to take place and it also leads to buckling of the positive plates. The cause of buckling is the formation of sulphate in the plugs of active material, causing them to expand, thus forcing the grids out of shape. If the plates are not discharged too far, the expansion of the active material is gradual.

Inspection

The cells should be inspected quite frequently. If the elements are in glass jars, an ordinary incandescent lamp will do for this purpose. The lamp should be held near the bottom of the jar, and by looking down between the plates, any foreign matter or material that may have lodged there can be detected and removed at once.

If the elements are in lead-lined or metal tanks, a submerged lamp should be used. The indications of trouble in a cell are: Falling off in gravity, color of plates darker or lighter than surrounding ones, and failure to gas freely at the end of charge. The cause should be looked for and removed at once.

Care of the Battery

Sediment should not be allowed to accumulate in the bottom of the jar, so that it reaches the bottom of the plates. It should be removed, the jar washed out, and the electrolyte put back with enough new electrolyte to replace that which was lost. When the specific gravity of a cell is lowered due to the loss through spraying at the end of charge, and absorption by the sediment, it should be brought up to 1.210 by adding 1.4 gravity acid.

If the battery is in use every day, it should be given an overcharge once a week to 0.005 specific gravity above that reached on regular charge, if possible. And until the maximum gravity for 5 successive 15 min. readings shows no further rise. All cells should be gasing freely. Before giving an overcharge, however, the evaporation in the cells should be replenished by pure distilled water, bringing the electrolyte in all the cells to as near the same level as possible. The electrolyte shoud never be allowed to get below the top of the plates.

The amount of electricity that may be taken from a cell, depends upon the surface of the positive plates, the normal discharge rate being about 0.0165 amperes per square inch of positive plate surface.

Changes in Voltage

Figure 4 shows the manner in which the e. m. f. of a cell falls as the discharge proceeds. The falling off is due to the weakening of the acid solution, and the reduction of spongy lead on 1 plate, and peroxide on the other, to sulphate. When the discharge is discontinued, the e. m. f. soon rises to its original value, as there is still much unconverted active material in the interior of the plate. If the discharge is resumed, the e. m. f. will fall rapidly to the value it had when the discharge was stopped.

Figure 5 shows the e. m. f. required to charge the same cell that gave the discharge in Fig. 4, it being charged at the same rate as previously discharged. It will be noticed that the cell was completely charged in 11 hr., and, as shown in Fig. 4, was discharged at the same rate in 10 hr. The ampere hour efficiency of this cell is then 10 ÷ 11, or 91 per cent.

ELECTRIC POWER IN A MALLEABLE IRON WORKS

SINCE the discovery that malleable castings could be made from cast iron, there has grown up an industry for the manufacture of this product which is one of the most important in our country. The Union Malleable Iron Co.'s works, a general plan of which is shown in Fig. 3, is a notable example, for since the first buildings of the factory were built in 1899, this company has steadily increased its output to the extent that during the past year over 10,000 tons of finished product have been shipped. The output of this factory is principally small castings for agricultural implements and those used in the manufacture of railway cars.

As is well known, the chemical element which causes the principal difference in the texture of iron is the percentage and state of combination of the carbon which it contains. Malleable iron is exceedingly tough and ductile, and is made by treating cast iron in an

oven, raising its temperature to a red heat which is maintained for a period of from 6 to 8 days, during which time the iron is decarbonized, with the result that the castings are made pliable and tough. The cast iron used in this process is a special grade, that preferred being either Cumberland hematite smelted in charcoal or white pig iron.

Foundry

In the moulding room of this foundry, which is shown in Fig. 2, are located 7 air melting furnaces, 10 tons capacity, made by the Whiting Foundry and Equipment Co. This cupola is used for melting the iron which is made into boxes in which castings are packed while being annealed. The 7 melting furnaces and cupola are all supplied with air through a common header or trunk pipe from one Sturtevant No. 8 fan, belted to a 30-hp. motor, 3 Sturtevant No. 7 fans, belted to 20-hp. motors and 1 Root blower, belted to a 20-hp. motor, all discharging into the same pipe and keeping the pressure such as to be sufficient for maintaining the blast.

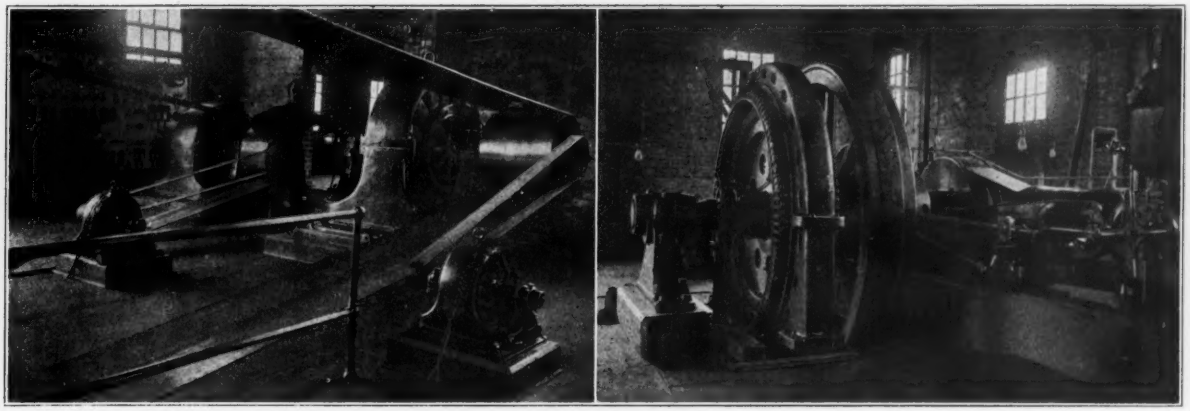


FIG. 1. ENGINE ROOM OF UNION MALLEABLE IRON CO.

each one having a capacity of 12 tons and are charged twice each day. These furnaces were designed and built by the superintendent, C. C. Heald, and consist of a firebox at one end, the gases from which are conducted over the pig iron to be melted and in this chamber are combined with air under pressure, sufficient to cause almost complete combustion. From

FIG. 2. MOULDING FLOOR

this melting department, the gases are discharged into the smoke stack. The furnace is made of fire brick and the top is so arranged that it may be removed in sections by a small crane. The iron is poured into the moulds by hand ladles as the castings are all small.

In the foundry room is also located a cupola of

Hard Iron Milling Room

After the castings have been poured, they are taken to the milling room and put through a course of cleaning which removes all sand and foreign material. The power used in this room is supplied by a 50-hp. motor, belted to a line shaft, from which the millers and exhaust fan are run. Each machine is supplied with an air pipe which gathers the dust from the castings, carrying it to a main pipe and then to the exhaust fan which discharges it. After castings have been put through the milling machines, they are assorted and chipped, thus putting them into condition for the annealing furnace.

Annealing Process

When castings come from the assorting and chipping rooms they are packed in cast-iron boxes as closely as possible, and around them is placed ground slag or some other packing which is quite rich in iron oxide. This packing is used to preserve the shape of the casting during the annealing process and also to decarbonize the iron. When the castings have been packed, they are placed in annealing ovens and there subjected to a uniform heat, which keeps them at a bright red color for a period of 7 days.

There are 17 of these annealing ovens in this room, all made of fire brick and each having a capacity of from 19 to 21 tons of iron. The furnace is placed at the rear of the oven, the gases passing through the heating chamber and down through openings in the floor near the front end and then through flues underneath the floor of the oven to the chimney. Thus a perfectly uniform heat is obtained on all sides and bottom of the oven.

For handling the boxes of castings, an electric crane operated by alternating current is used. This crane has a capacity of 5 tons and a span of 52 ft. and was made by the Whiting Co. The ovens are not accessible by the crane so an air motor is used

by means of which the boxes may be placed at any position in the oven.

After the castings have been subjected to this annealing process, they are again milled and assorted and sent to the finishing room or machine shop, where the necessary holes are drilled and the castings finished, ready to be used.

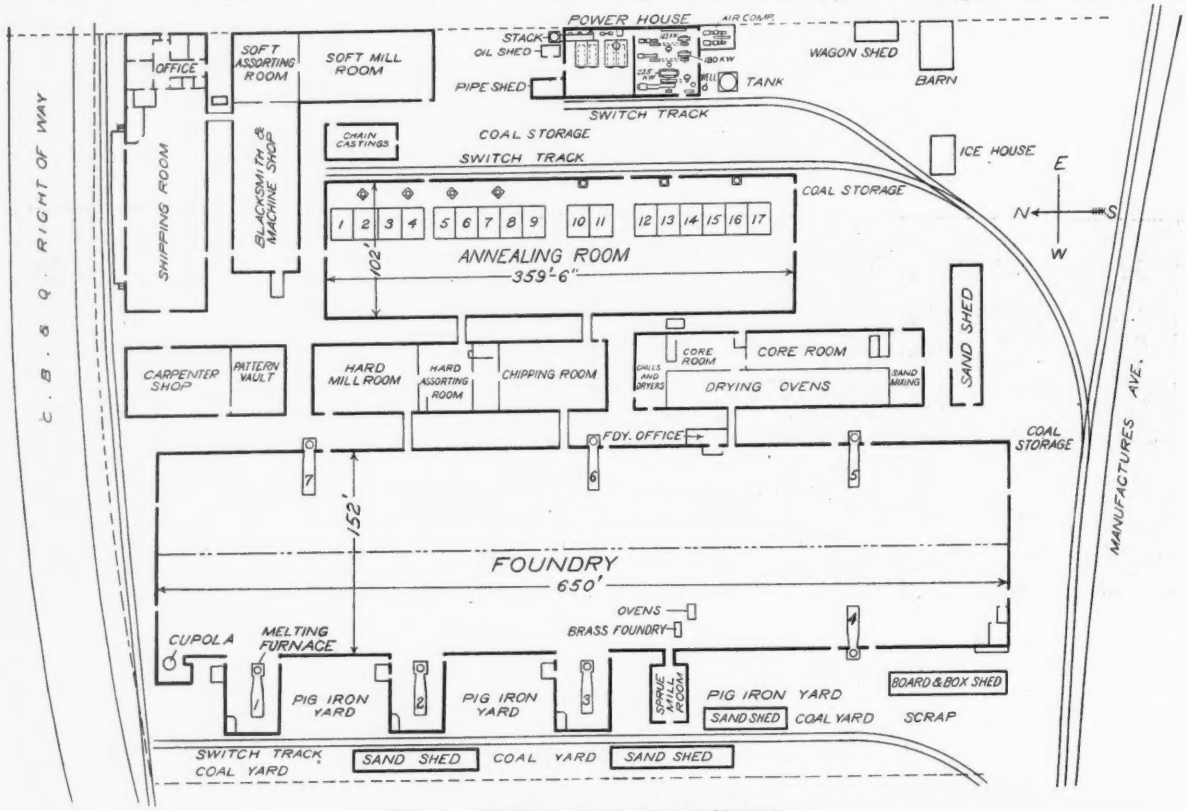


FIG. 3. GENERAL PLAN OF BUILDINGS

Core Making

In the making of the cores for use in this foundry, pulverized rosin and sand are employed, mixed in such a proportion as when baked to give a hard core. In the sand mixing room a 5-hp. motor is employed to pulverize the rosin and screen the sand, the final sifting being done by a shaking screen operated by an Ingersoll air ram. The core material is then sent to the core moulding rooms, where it is made up into the proper shapes and the green cores are then placed in drying ovens for a sufficient period to bake them thoroughly.

Lighting System

The lighting of this plant has been well worked out to suit all conditions under which the plant is operated. The work is such that all operations requiring close observation of details in construction and machining are done during the day shift. During the night what is called the clean-up gang is at work getting the foundry and other parts of the plant in shape for the next day.

To meet these conditions of lighting what might be an insufficient supply of artificial lighting for many plants of the same space where the character of the work is different, is entirely satisfactory in this plant.

During the daytime the foundry and annealing rooms are lighted by skylights which extend the entire length of the buildings and in other parts of the plant large windows are placed at frequent intervals in the most convenient locations to supply the necessary light.

The artificial lighting is done entirely by electricity,

FIG. 4. BOILER ROOM

there being installed a total of 54 arc and 587 incandescent lamps. All arc lamps are of the Westinghouse multiple alternating-current type and are con-

nected to the same lines as the incandescent lamps, which are all 16 candlepower carbon filament lamps. The total floor space of the plant is 207,000 sq. ft., which gives an average of 0.285 watt per square foot. This is, of course, distributed to give the best results.

In the foundry, over the center of each aisle, is a row of arc lamps hung about 20 ft. from the floor and 54 ft. apart, supplying light the full width of the aisle, 76 ft.; this makes 4,104 sq. ft. to each lamp or 0.12 watt per square foot.

The annealing room is lighted in a similar manner with the exception that the lights are higher to make way for the traveling crane. In this room, however, there is only 1 row of arc lamps, placed over the working floor, while at the rear of the furnaces incandescent lamps are used for the convenience of the stokers.

Arc lamps are installed in all of the large rooms and in addition to these where there are benches, desks or machines, where the detail work is done, each is supplied with an incandescent lamp. The power house is lighted entirely by incandescent lamps which are better for this purpose than alternating-current arc lamps, as the light does not flicker so perceptibly.

The lighting circuits are run direct from the switchboard in single phase, 440 volts, to transformers which change the voltage to 110, making it satisfactory for the lamps employed. There are 6 of these transformers which are connected in such a way as to give a perfect balance upon the 3-phase system of the power plant.

Boiler Room

The power house which supplies all light and power for the plant consists of a boiler and engine room. The steam generating system is a battery of 4 boilers, each of 150 hp: rating. Two of these boilers are of the Babcock & Wilcox make, consisting of 81 4-in. water tubes, 16 ft. long, and 1 drum 42 in. in diameter by 18 ft. 4.75 in. long. The flue gases from these boilers discharge into a breeching, which leads to a 4-ft. stack, made of brick for 30 ft. high, topped with 55 ft. of metal.

The other 2 are Geary boilers, made by the Oil City Boiler Works. These are also of the water-tube type, having 80 4-in. tubes, 16 ft. long, the gases discharging into a 4-ft. metal stack, 100 ft. in height. All boilers are equipped with Reliance safety water columns and the steam from all is carried to the engine room through one common 12-in. header.

Water is supplied to these boilers by means of a Worthington duplex pump, 7.5 by 5 by 6 in., and a Marsh pump, 7 by 4 by 8 in. A 500-hp. Cochrane feed-water heater is employed in the plant and the Evans-Almirall exhaust hot water heating system is used for heating the entire factory from the boiler room. For this system 2 centrifugal circulating pumps are employed, both of the Evans make, one 30-in., driven by 2 vertical 4 by 6-in. Lawrence steam engines, direct connected to the pump. The other circulating pump is direct connected to a 15-hp. motor, the diameter of the pump being 12-in. and its speed 1,120 r. p. m.

Water from the returns of the system is pumped to an exhaust steam heater, which is supplied with steam from the feed-water heater. From this heater the water is carried through a live steam heater and then to the various radiators of the plant.

The water used in the entire factory is supplied by 2 wells, one 202 ft. deep, from which the water is drawn by an American deep well pump, which has a 4-in., double-acting water cylinder and a 6 by 24-in. vertical steam cylinder, this pump being located in the engine room.

The other well is 180 ft. deep and is operated by air lift, the water pipe being 3 in. and the air pipe ¼-in. in diameter. The water from these wells is discharged into an elevated tank from which it is piped to the various parts of the factory.

Engine Room

In the engine room are 3 Buckeye engines. One is a compound 9 by 17.5 by 21 in., running at 165 r. p. m. and belted to a 75-kw. 3-phase generator, of the Westinghouse stationary field compensating type running at 720 r. p. m. Steam is supplied to this engine through a 3.5-in. pipe, in which is placed a steam separator. The belt wheel of this engine, which is also the flywheel, is 11 ft. in diameter, and sight feed oiling cups are employed.

The second engine has a single cylinder 17 by 24 in. It is belted to a 180-kw. Westinghouse generator, similar to the one described above, which runs at a speed of 518 r. p. m. The steam supply of this engine is carried by a 6-in. pipe, in which is also placed a steam separator. On this engine the Buckeye gravity oiling system is employed, and the valve gear is of the riding cutoff piston type. Here again the belt wheel serves also as a flywheel and is 9 ft. in diameter. The third generating set consists of a Buckeye engine, 18 by 30 in., direct connected to a 125-kw. Westinghouse generator, of the revolving field type, which is operated at 150 r. p. m. A gravity oiling system is employed here also and the steam supply carried in a 7-in. pipe. The exhaust from all the engines is piped to the feed-water heater which has an efficient oil separator attached to it.

Each generator has belted to it an exciter, these supplying direct current at 125 volts, each of sufficient capacity to take care of the generator to which it is connected.

Current Distribution.

The switchboard consists of one double panel, and one single panel, the first being supplied with 2 ammeters and a voltmeter and necessary connecting and distributing switches for operating the 2 belted generators. The single panel board contains one voltmeter and one ammeter, together with necessary switches for connecting the direct-current generator to the line. These generators are so connected that they may be operated in parallel, lamps being employed in the operation of synchronizing.

All power circuits carry 3-phase currents and supply Westinghouse induction motors of the squirrel cage type. The great amount of dirt and dust which is encountered throughout the plant makes this type of motor almost a necessity. In a number of cases the motors are enclosed in sheds to protect them from the dirt.

In the engine room is located also a Marsh air pump to supply air for cleaning the generators. This pump is of the single-acting type, 10 by 8 by 12-in., and is equipped with a Fisher governor to control the reservoir pressure.

In an addition to the engine room is a Bury air compressor, compound type, 10 by 10 by 10 by 10 in. which supplies compressed air at from 80 to 100 lb. pressure, for use in the air truck for handling the castings in the annealing room and for various other power purposes around the plant. This compressor is supplied with an unloading device or pressure regulator, made by the Jarecki Mfg. Co., which operates to maintain a constant pressure on the air line.

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WARNING

D. D. Fennel, who carries a subscription book numbered from 9051 to 9098 and who has been operating in Indiana, has been defrauding engineers and all are cautioned against doing any business with him. Reward will be paid for information as to his whereabouts which leads to his discovery.

THE ISOLATED PLANT

Good engineering in any line depends on the best adaptation of means to an end. Evidently the running of an isolated electric plant to light a city residence of moderate size would be sheer folly, for there is no possibility of doing it as cheaply as the current can be bought from the central station. This is true of the small shop or the small retail store where the heating is either furnished by the landlord of the building or done by a furnace or small hot water heater which is tended by the proprietor or the office boy.

Where, however, an establishment requires the use of steam for heating, and especially where an ice-making plant is run, so that the purified exhaust condensation is wanted for making ice, the cost of electric energy for lighting and motors becomes simply that of the interest on the generating units and a slight additional cost for attendance. Boilers would be a necessity anyway, to give the steam for heating, and the extra coal required to furnish steam at high pressure is but a slight addition to that required for low-pressure steam. The extra room required for the generating units and switchboard is usually in such location that it would be of value for nothing except storage, hence the rent charge may be eliminated.

In but few buildings or factories is it the case that there is no call for steam except to run the generator engines, and where the exhaust steam is needed for heating or industrial purposes a cost of 2 cents a kilowatt-hour is reasonable for the expense of electric energy over heating alone even in a plant of small size.

Another advantage of the isolated plant is that the generating system can be laid out giving current best adapted to the needs of the plant, while, if current is taken from central station mains, the lighting outfit must be adapted to the current available.

In any isolated plant it is essential, however, that careful management should be the rule so that the costs be reduced. Wasteful management means failure in a central station and even more in the isolated plant, where the balance between profit and loss is usually smaller than for the big company. Every case should, of course, be decided on its own merits, but there is no reason to feel that the isolated plant has outlived its usefulness or that it ever will do so.

LATEST DEVELOPMENTS

For centuries effort has been made to devise a means of getting electric current direct from coal, but without commercial success. Unquestionably our present method is crude and wasteful of fuel. Unques-

tionably also we must find some means, as the supply of fuel becomes less plentiful, of getting better results.

We can hail the work of the United States Geological Survey as of the greatest benefit since it has proved beyond question the possibility of burning all kinds of fuel, even the poorest, in properly designed furnaces, at good efficiency and without the production of smoke. But the most wasteful step, that of passing the steam through an engine, is still there. The gas engine has pushed the efficiency of this conversion up a notch, but, even at that, it is far from the ideal and many scientists are looking forward with apprehension to the fate of our grandchildren 100 years hence, when the supply of fuel will be practically exhausted.

All our fuels as now used are simply stored energy from the sun. This is true of coals, oil, natural gas and wood. Three sources of continuous energy from the sun are available and it is to these we must look for our power, probably even for our heat, in the centuries of future development.

The water power, which comes from the raising of vast masses of water from the ocean's bed by the sun's rays and deposit on the high levels, is always with us and may be preserved by proper forestation and storage reservoirs. This work is being rapidly carried forward and if the tendency to gather these natural resources all into the hands of a few large companies is restricted this power may to a considerable extent be available for the whole nation. The flow of currents in rivers where there is not sufficient fall to make the gravity head available has so far gone to waste, but may be made a considerable source of power with proper control. Wave power from the winds and tidal flow from the moon are in this same class. The direct rays of the sun falling upon the earth's surface furnish a source of power which has been estimated at 2 hp. per square yard in bright sunlight. We do not quite grasp the significance of this until it is considered that on every city lot 25 by 100 ft. energy is expended on every sunny day at the rate of 250 hp.—sufficient to light 2,500 incandescent lamps.

The problem of gathering up this energy has been attacked frequently but without great success up to the present time, and in all previous developments has utilized some form of steam generator and the inefficient steam engine. Now comes a scientific genius, George H. Cove, of Massachusetts, who makes use of the old familiar principle of the thermoelectric battery and turns the sun heat direct into electric current. The secret is, of course, in the metals which he uses; that he naturally does not divulge, but the statements made in regard to his invention have the ring of practicality and tie up with facts and figures.

In the latest type of "solar electric generator" the couples are set so that one end is in the bright sunlight, covered by a glass case to prevent air currents which would cool them, the other at the back of the frame in shade and cool air. A matter of a thousand of these cells are set into a sash 5 ft. square.

This device, which may cost in the region of $100, simply stands on the roof facing the south, and is stated in one sunny day to send sufficient electric current into a storage battery to light the ordinary dwelling for a week. This is within the probabilities. The frame will have an area of 25 sq. ft. or 2.5 sq. yd. It will, therefore, get energy at a rate of 2.5 hp., which, allowing 8 hr. of the day for active sun, would give 20 hp. hours stored in one day. Allowing 7 16-candle-power lamps and 10 lamp-hours to a horsepower, this would give 30 hr. of burning or 4 hr. a day for a week. Even allowing for loss of energy in the circuits and storage battery this would be generous for the lighting of the ordinary dwelling.

Carried to its logical conclusion this would mean simply that every house would be its own electric station when the future development is completed; for a sash 10 ft. square equipped with these couples would take care of the heating, lighting and cooking of the ordinary dwelling without attention except to keep the storage battery in order, and a factory building would need only have its roof constructed of the sash under which were placed these couples in order to give it sufficient power to run its machinery.

Like all new scientific developments there is chance for a snag somewhere, but, if this proves up what it seems to promise, the provision of power and heat for future generations would seem to be placed outside our proper field for worriment.

WASHING

Whether or not washing of coal is advisable has for a long time been a debated point and it is quite certain that, for many kinds of coal, washing removes more volatile matter which is valuable in the fuel than it does of dirt. For certain of the coals in the western part of the country, the tests conducted in the fuel testing plant of the Geological Survey at St. Louis prove that washing is advantageous and also proves that many of the coals heretofore deemed of no value for making coke can by proper treatment be made available for that purpose. The tests made during the past year have just been reported upon by the survey and show that of 37 coals tested all but 3 produced good coke under proper treatment.

The investigations were carried on in connection with the general purpose of the government to increase efficiehcy in using the fuel of the country and the washing tests of coal in particular were to determine whether this would make the coal available for the production of coke. For this purpose coal must be free as far as possible from ash, sulphur and other impurities, because these impurities make the coke of no use for smelting and other processes in the reduction of metals. The tests showed that many coals which have too much ash and sulphur to be used economically for steam boiler fuel or in the original condition for cokeing, may, by treatment in the washery, be so cleansed as to give coke available for the blast furnace.

PREPARING FOR SEA

By M. E. P.

AT THE very beginning of this article I want to make it clear that it is written for the benefit of engineers who are taking charge of a strange ship and one which has been laid up for some time, such as is the case on the lakes during the winter months. The duties which devolve on an engineer in such a case are somewhat different from and much more arduous than those which confront his brother ashore. The difference in the work is not so much in the kind as the amount involved.

If the main engines have been dismantled and the parts stored away, it is an undertaking of some magnitude to get them out, cleaned and properly assembled and adjusted. It calls for the constant care and presence of the chief or some assistant in whom he has complete confidence, and right here is one of the greatest difficulties which confronts the new chief. He is often an entire stranger to his force and does not know anything about the skill or reliability of the men under him. It will take some days to determine these matters and in the end he may not feel sure that the man who has the most skill is entirely to be trusted to do his work properly unless he is closely watched.

Cleaning and Inspecting

The rough work of cleaning parts is left to the poorer class of his help and sometimes extra laborers are hired for this purpose, but the parts as they are cleaned must be carefully inspected to see that they are sound and are in fit shape to be put into their places. This means that pins and flat sliding surfaces are not worn too much to be serviceable. Cylinders should be inspected and tested for roundness and the fit of pistons verified. In assembling the moving parts, each piece should be adjusted as it is put in place, as nearly as possible to its proper working tightness. The thrust block should be carefully looked after and the shaft inspected for its entire length. All of the more important work should be personally inspected by the chief as it is completed and he must be sure that it has been done carefully and thoroughly.

While the work of assembling has been going on in the engine room, he has had a force of men at work in the fire room or "stoke-hole," the boilers have been cleaned and inspected and any repairs necessary have been made. All of the piping system has had a thorough overhauling and valves and other fittings have been packed and seen to be in good working order. The donkey boilers and engines of all kinds must be seen to and condenser, bilge and other pumps must each receive its share of attention and care.

The Electric Plant

If there be an electrical installation aboard, it will require a great deal of attention and some of the work in preparing it for operation is of particular interest. The generating set will likely be of the vertical, direct connected type taking steam from the donkey boiler as that boiler is always under steam. There may be several motors taking current from the generator as well as the lights for the ship. As a matter of practice, the usual way of starting to work in preparing for sea is to overhaul the donkey boiler and connections first and then turn to the electric generator set as the lights will be needed constantly while the other work is progressing.

The Engine

There is nothing about the generator engine that calls for peculiar treatment with the exception of 2 points which will be noted. It is well to examine carefully the end play of the shaft and see that it does not exceed the amount of end play allowed on the connecting rod pins and in the eccentric. This play should always be as small as possible and be safe from end binding when the parts heat up. A great many thumps are to be traced to this cause and much annoyance can be prevented if measures are taken to keep it as small as possible.

The other point is the fit of the piston in the cylinder. A piston that is too loose and that has not springs strong enough to hold the weight of the piston when the ship is in a sea way will pound badly, and at times is dangerous.

The Generator

The generator calls for somewhat more care than is usual ashore and the method of testing and preparing for service may be of interest. With a good magneto, test the commutator to see that it is all right and then test the field winding in the same way. If this test is satisfactory, connect a large cable to each bus bar on the switchboard and lead them all over the side with old grate bars attached to the ends. Thus you have a first-class water rheostat and with it an easy means of drying out your generator.

Open all the switches in the circuits leading out from the board; close the main switch and start your engine slowly. You will get a large amperage at low voltage, the amount of current being regulated by the distance you separate the terminals in the water. The generator will quickly heat up and by running slowly you can get a steady drying heat in all the coils of the generator. When you are satisfied that the generator is dry, shut down the engine and as quickly as possible make a second test with the magneto and, if everything is clear, it is safe to conclude that the generator is ready to take a load.

While the generator has been running on the heating load, the several circuits should have been inspected and the magneto test applied to them. If the magneto rings clear on all it is safe to put them in service. The motors may then be tried and used as much as possible for a time to see that they run all right.

The electrical equipment will now go into steady service as the current will be needed for lights and power while the rest of the work of preparation is going on. A close watch should be kept on the circuits from the switchboard for a few days and all wiring which is exposed to dampness should be particularly watched at all times. None of the auxiliaries is more important than the generator set and on none does the comfort of passengers and crew more depend.

Trying Out

When the main engines are assembled and adjusted as well as possible, the boilers ready to put in service, the condensers clean and tight, it is time to

make a preliminary trial. Get up steam and start the main engines at a slow speed and run large quantities of oil through all the bearings so as to wash them out thoroughly. Watch for heating in all parts of the engine and also for lost motion. See that the pumps are all working well and that the condenser is doing its work properly. As fast as defects are found—fix them. Be sure that every single thing about the ship is in as perfect working order as it is possible to make it. It is the little things which grow to be big ones when you get to sea and you just have to work your engines.

Getting Up Steam

Perhaps a few words about raising steam will not be out of place just here. I believe in taking plenty of time to get your boilers hot. It is much better to take 10 hr. to get steam up to working pressure than it is to get it in 2 hr. Make a small fire in the furnaces at first and build it up gradually. Anything rather than forcing at this stage of the game. While the boilers are warming up, have the stop and throttle valves open to all the engines aboard ship, let everyone of the steam pipes get warmed slowly and all together and there will be less trouble than if you try one at a time. When steam begins to blow through the various lines, close the throttles on the engines and let the pressure rise slowly. I usually leave the throttle to the main engines open a little and put the gear on the center so that the valves will warm up, and also have the bypass to the intermediate and low-pressure cylinders slightly open for the same reason. The temperature of the engines will rise with the pressure in the boilers and when you are ready to turn over the engines they will be thoroughly hot.

Of course, the engines are first turned over by hand or with the starting engine, if there is one, and the engineer will be sure that everything is clear, that no tools have been left in the crank pit or lying about where they may be caught in the moving parts. Work the engine back and forth with the reversing gear and be sure that everything is all right before allowing the engines to turn over the center. Approach the center very slowly and let her go over once or twice before giving her more than just a crack of the throttle. Gather speed slowly and watch the condenser to see that it is working well and is holding the vacuum up as it should. After she has been running on the "ahead" gear for a while, reverse her and let her run on the "back" or "astern" gear.

After all this preliminary work has been successfully done, it is well to get a few indicator cards to verify the valve setting. Have the mate tie up the ship as securely as possible so that you can run hard enough to get a fair card from each cylinder. Make whatever adjustments are necessary and make a final inspection to see that nothing is out of place or missing and you are ready to go to sea as far as the engines are concerned.

Laying in Supplies

These few details do not comprise the entire list of the things which the chief of a ship has to do, in fact are only a fair part of the total duties which devolve on him. He must look after supplies, see that sufficient material of all kinds is purchased and put aboard, that the ship is coaled, that the tanks are full of water, that the firemen, coal passers, water tenders, oilers and assistant engineers are competent to do their work and a few other odd jobs with which he can fill in his leisure moments. By the time the ship has left the dock and is well under way, the chief may begin to think that he has been rather busy for a few days and feel as if he had earned a watch below.

In spite of the numberless things which must engage the attention of a good chief engineer aboard ship in preparing for sea, it is really a matter of wonderment how calmly a good man will proceed with his work and how much he can get through in a day. He is never hurried and still he seems to be everywhere at once. One of the assistants wants him on deck to look at something about one of the donkeys and within 2 min. he will be found in the stoke hole directing the work of a boilermaker who is busy putting on a patch and in another 5 min. he may be on the bridge testing the signal apparatus. How he gets around so quietly and so quickly no one seems to know, but there he is every time just where he is the most needed.

This faculty of being able to supervise coolly the numberless details which he must look after is one of the hall marks of a good engineer. It commands the respect of his crew and also that of the deck officers. The captain feels that he can rely on him in any emergency and the engineering force feel that in case of trouble he will pull them out of the hole without fail and in the least possible time.

I was about to say that such men were rare, but on second thought I do not think them so rare as one would at first suppose. There are few men who have risen to the rank of chief who are not reliable in time of trouble and danger. The resourcefulness of marine engineers is a constant wonder to those who know them best. The number of lives that are saved annually by the presence of mind of engineers of all classes would be hard to compute, but it is safe to say that no class has a greater number to its credit than the marine engineer.

STEAM ENGINES FOR GENERATING SETS THE REAL VALUE AND SUITABILITY OF THE MODERN RECIPROCATING ENGINES FOR SUCH USE

By A. M. Morse

REFERRING strictly to engines for electric lighting and power plants, the elements of reliability and economy in the order named, with all that the terms mean, determine the real value of a steam engine.

Certain it is that the mere matter of price should be the very last consideration in the selection of so important an element of a power plant, as the prime mover.

Reliability

Reliability, which means uninterrupted service, is the direct result of careful and correct design and the use of none but the best grades of materials throughout, strictly adapted to the service and properly put together; this means intelligent selection of metals, often expensive, which will wear well and not require frequent expensive replacements, involving costly shut downs in addition to the actual cost of the new parts.

It would surprise a layman or novice to know what a large reduction can be made in the cost of an engine in sharp unscrupulous competition and at the same time not be noticeable on casual inspection.

A comparatively trivial expense in outside finish, nickle plated trimmings, etc., gives the engine an attractive appearance, but only actual work and service will develop the results of cheap construction and

inferior materials and workmanship; it is then too late to rectify the mistake which has been made in the selection, except by an entire replacement of the engine.

Lubrication

As to methods of lubrication it is getting to be quite a general practice of progressive engine builders to embody in the construction of the engine an automatic system of lubrication, thus effecting not only material savings in the oil bill over the old fashioned methods, but at the same time giving positive insurance against the failure of a continuous needed supply of oil. This method of lubrication reduces internal friction, prolongs the life of the engine and saves valuable time of the attendant, which would otherwise be required to watch a score or more of sight-feed oil cups necessary for the old fashioned open type of engine, and which are almost sure, soon or later, to be neglected if the engineer has other duties, and the parts requiring oil thereby run dry, causing excessive wear and a possible shut down to make repairs.

Automatic lubrication can be effected either by a system of piping and oil cups supplied by a force pump or gravity system, or by centrifugal action of a special crank disk which delivers the oil to the crosshead shoes and pin, and at the same time furnishes by gravity supply a steady stream of oil to the main journal and crank pin; all of the oil is carried back to a central reservoir and when necessary it can be filtered. The cylinder is usually supplied with a mechanically operated force pump and the eccentric by gravity feed.

The latter method if properly designed and constructed is preferable to the pump and pipe system, being simpler in construction and less liable to derangement.

Given a well designed and carefully constructed engine as regards the bed plate, the main shaft and crank, and the shifting parts, such as the piston, crosshead and connecting rod, the vital features which really determine the steam economy of the engine and the regulation consist of the valve motion, which embraces the valves and the operating mechanism, and a well designed governor which shall control the speed by direct action on the admission valves suitable for electrical service.

Valve Motion and Economy

Regarding valve motions, volumes have been written and a world of patents have been issued. Valves can be classified into slide valves, Corliss valves and poppet valves. The latter type has never been generally adopted in this country, so the other 2 classes of valves only will be referred to.

Economy of steam means not only keeping the coal bills down, but at the same time getting a resultant reduction in the wear and tear of the boiler equipment, which is important, especially in large plants.

In order to obtain steam economy, or in other words, to operate the engine on the least amount of steam per horsepower-hour, it is of vital importance to avoid steam leakage. The admission and the exhaust valves must be steam tight to begin with, and they must be so constructed and placed in the cylinder or steam chests that they will continue to be steam tight and not require constant refitting of the valves and seats, which not only is expensive but necessitates a complete shut down of the engine for repairs, or else continued operation wastefully.

Slide valves suitable for engines for electrical service may be either of the flat balanced type with a pressure plate, or of the piston type, either with or without rings and either fitted to the valve seat in the cylinder casting or fitted in a cage or bushing, which is removable from the main cylinder casting.

Single Valve Engines

Most excellent results have been obtained with single valve engines of either of the types named above and they are especially suited to high speeds, from 250 to 325 r. p. m.

Releasing Gear Corliss Engines

In order to obtain the best steam economy in engines for electrical service it is quite the standard practice to use 4 Corliss valves. Splendid results have been obtained from refinements of the standard releasing gear brought out by Geo. H. Corliss more than 40 yr. ago.

The standard Corliss releasing gear type of engine has been greatly improved and while the speed for which this type of valve gear was originally designed was from 50 to 60 r. p. m., the best releasing gear Corliss engine of today will operate very satisfactorily at about 100 r. p. m.; while they are frequently installed and forced to a speed of 125 r. p. m., the practice is condemned by conservative engineers, as the feature of unreliability is introduced.

The standard Corliss releasing gear type of valve gear has been adopted by a large number of engine builders of the country, all being on the same general lines with slight modifications in detail. Any releasing or trip gear, however, is restricted to a speed limit, which has been found to be at about 100 r. p. m.

Nonreleasing Gear Corliss Engines

Medium speed Corliss valve nonreleasing gear engines have been attracting attention recently, the engines being designed with a heavy duty frame, with positive nonreleasing gear valve motion which can be operated easily and reliably at speeds of 200 r. p. m., yet retaining the cylindrical rolling Corliss valve with its acknowledged advantages over any other type of valve.

Single cylinder noncondensing engines of such a design have shown in tests remarkably good efficiency, being a most highly efficient and desirable type of engine for an electric generating set, and while such an engine unit naturally is more expensive to build than a standard releasing gear Corliss engine, because of design material and workmanship to withstand the high speeds, the reduced cost of the generator, because of the increased speed, is an offset or more to the difference in the cost of the engines; furthermore the improved efficiency and the saving in floor space and the building, leaves hardly a question of doubt in the mind of the writer as to which type of engine to select.

Miscellaneous Engine Types

In the efforts of the engine designers and builders to make something different from accepted standards, there have been put on the market at various times, engines having 2, 3 and 4 or more valves in 4 cylinders, also a 4-ported engine, having really but 2 valves, but erroneously called a four-valve engine.

In the design of these engines has been adopted a variety of constructions of flat valves, piston valves and semi-Corliss valves, but the majority have been shown in service to be little, if any, better from an efficiency standpoint than a well designed and carefully built single valve, high-speed engine.

The result of an economy test, brought to the writer's notice, made on a 4-ported, 2-valve engine, which had sold as a "4-valve" engine, showed an efficiency of no better than 42 lb. with an initial pressure of 110 lb., such a remarkably poor showing being undoubtedly because of leaky valves. In fact on account of these valves and seats being flat there was almost sure to be leakage, not only of the steam valves, but of the exhaust valves as well, and on account of the expense incident to the refitting of the valves and seats, the latter being a part of the cylinder casting itself, the losses due to the leakage are likely to be neglected until such time that they become so serious as to make it absolutely imperative that the work be done.

A notable exception to both of the general types of valve gear referred to in the foregoing is a construction adopted by some prominent eastern engine builders, in which the valves are of the gridiron type, having a short travel and being operated by cams or link motion; excellent results have been shown with these.

Governors

The governor of the standard releasing gear type of engine is in nearly all cases of the pendulum or flyball type with modifications and does excellent service, but better results are obtained with some forms of automatic engines by the use of a centrifugal inertia flywheel type of governor, secured to the main shaft of the engine, and an improved form of this type of governor is used in connection with medium speed Corliss valve non-releasing gear engines referred to; it has been found to give much closer regulation than is possible with the pendulum type.

In conclusion, while it is quite generally conceded that the steam turbine, when operated in connection with high vacuum auxiliaries and suitable condensing water supply, has come to be the standard apparatus for the largest steam driven generating sets; nevertheless, based on tests of actual performance, the reciprocating steam engine has several points of advantage over the turbine, especially under noncondensing conditions; and for units of 1,500 hp. and smaller, the improved and refined type of reciprocating engine will hold its own for years to come as one of the best forms of prime mover for generating sets in electric lighting and power plants.

POINTERS FOR THE ICE PLANT.

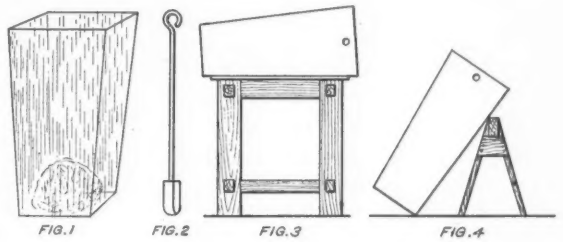
By Harry Double

A FEW days ago we found about a gallon of water trapped in the bottom of our can ice, as shown in Fig. 1, and I would like to know what caused it.

In the tank where it happened the expansion is in the top of the coils and the suction on the bottom; the brine is circulated by a low service duplex pump. I have been making ice in this tank for 12 yr. and this is the only time anything like it happened.

As there are always more or less leaky cans around an ice plant it is necessary for somebody to be able to repair them. I have had considerable trouble trying to get cans soldered and have not found a tinner or a plumber who could solder cans so that they would hold for more than 2 or 3 freezings, when they would be as bad as ever. Then I did not have time to try it myself as I was running the engine and that took all my time.

Now as I do only the repair and extra work I bought a couple of irons and took a hand at it and I have no trouble making them tight and to stay that way. There probably are many ice men who do not need to be told anything about the ice business, so this is only for the ones who don't know. In the first place, I could not get the kind of coppers or soldering irons I wanted, so I bought a pair of 6-lb. irons. I have a blacksmith shop, so I make them square at the point instead of pointed as the tinners use them, then I



ICE PLANT APPARATUS

welded long handles on them so that I could reach the bottom of the can without putting my head inside and swallowing all the acid fumes.

When soldering do not try to scrape the can, just use plenty of muriatic acid, use it raw, as it will get plenty of zinc off the galvanized iron; keep your irons just as hot as they will stand without burning the tinning off and do not be afraid to put some solder on. If you cannot make a smooth job do not get discouraged, for it is difficult to get it smooth. Heavy hot irons, plenty of acid, the best of solder, a little experience and some patience will do the job.

For convenience I made a bench high enough to work on, about breast high, so I could look in the can without stooping too much; this is for split seams on the sides. For working on the bottom I just use a sawhorse to tip the can over on, as you will see by Figs. 3 and 4. Fig. 2 is the way I made my iron.

FINDING A SPRINKLER LEAK

Not long ago an engineer had a sprinkler system extended into a new building in his plant. It was of the dry type with compressed air pumped into the pipes to hold back the water. When she was all done, they filled her with air at 85 lb. and, behold, after 2 days there was only 35 lb., which same ought not to have happened for over 6 weeks.

Soap lather treatment to the joints could give no hint of the location of that leak,—but it was there just the same.

Our friend, the engineer, was a man of resources and says he, "We'll chloroform the leak, and that'll put it to sleep so we can catch it napping easy." So he forthwith got 3 oz. of ether, poured it into the suction of the air pump that filled the sprinkler pipes and started the pump, in which case the ether went into the sprinkler pipes.

Foremen of departments were warned to watch for the odor of ether, and report to the engineer. A day passed and no report; the ether wasn't yet working. But on the second afternoon word came that the leak was etherized and captured in a joint on the old system close to the new addition, caused probably by the strain when installing additional piping. So much for perseverance and using one's think tank. If you can't do a thing one way, do it 2 ways.

GAS ENGINES AND PRODUCERS

THE MAXIMUM EFFICIENCY GAS ENGINE

Seeking a name to justly represent this heavy, sturdy engine, the makers, The Tower Engineering Co., of Buffalo, N. Y., have christened it The Maximum Efficiency Gas Engine, because of its high compression, and consequent necessary heavy construction, its method of adjusting the mixture and ignition in governing to get the most power possible from the fuel, the system of circulating the cooling water to maintain an even temperature to all parts of the engine in contact with burning gases, the force feed lubricating system with its adjustable sight feeders through which can always be seen by the operator the amount of clean filtered oil being fed to each bearing.

Figure 1 gives some idea of the features that go to make up this machine and its strength and compactness.

Crank Housings

The walls of the engine base or lower crank journal housings are from ¼ to ½ in. heavier throughout than usual practice, with the foundation bolts received

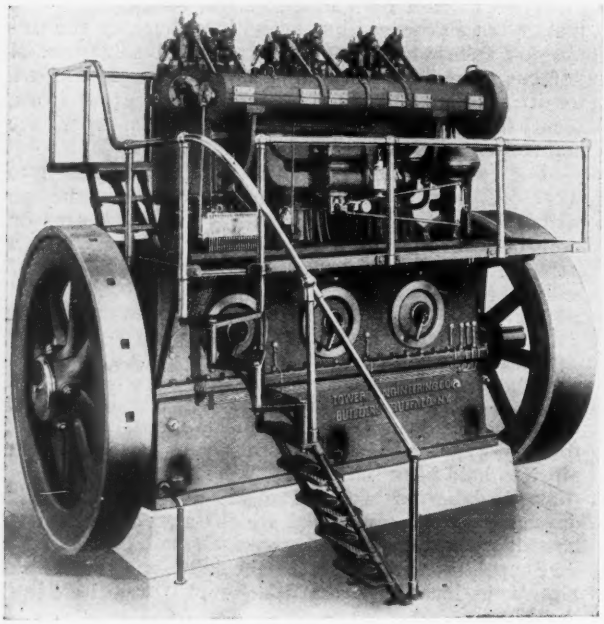


FIG. 1. THE TOWER MAXIMUM EFFICIENCY GAS ENGINE

in anchor pockets cast in the side of the frame, thus in no way interfering with the oil drain or trough around the outside base. Inside of this base are located the main journal or crank bearings, which are constructed with a large factor of safety, and have supports cast integral with the lower crank case or bed plate.

All bearings have wedge adjustments so that wear can be taken up and alignment made in a moment by means of a threaded adjusting rod extending through to the outside of the crank case with lock nuts to hold it in position.

These main journal bearing supports are securely bolted on the inside of the case to broad ribs that are cast integral with the upper crank case and which tie the upper and lower crank cases firmly together to resist the strain of the power stroke. On the under side of the upper case are a heavy boss and ribs which support the part of the cylinder that projects down into the crank case. Both the liner and outer wall of the cylinder are carried downward to form a bearing for the long trunk piston.

Cylinders

The outer cylinder wall is strongly reinforced at the waist by heavy ribs between each holding stud bolt that secures the cylinders to the case. To give some idea of the liberal strength embodied throughout the entire design; each 16.5 by 18-in. cylinder of the 200-hp. engine is fastened to the crank case with 20 1-in. steel stud bolts, as indicated in Fig. 3.

The liner consists of a plain cylinder carefully machined on both inside and outside on a special machine which produces a perfectly round and smooth surface, the inside of the outer cylinder being bored to obtain a close fit against the spiral fins that serve as a water guide to the cooling water. The liner is pressed into the cylinder and firmly held in place by a

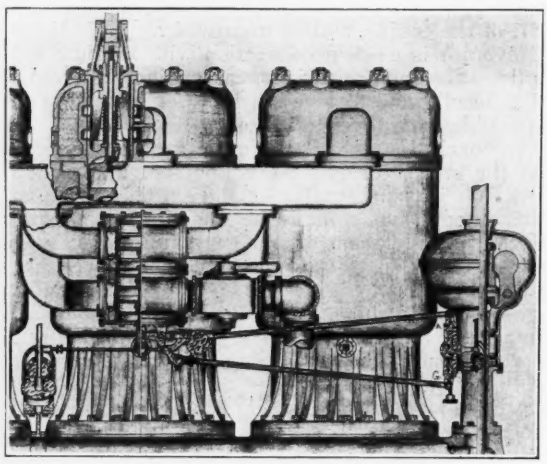


FIG. 2. GOVERNING CONTROL OF AIR, GAS AND IGNITION

flange securely bolted between the top of outside wall and cylinder head. This construction allows for independent expansion of the liner and outside jacket.

The cylinder head is securely fastened to the cylinder and liner by heavy steel studs passing through the entire depth of the head. It contains the inlet and exhaust valves and is cored for a large water cooling passage, for the exhaust gases; also 2 passages to the inlet valve, one for gas and one for air. Ample provision is made for openings to enable the cooling water space to be inspected and cleaned.

Valves and Valve Gear

Both inlet and exhaust valves are of the vertical poppet type, and open directly into the cylinder requiring no pockets, but allowing a symetrically rounded shape to the clearance chamber, thereby minimizing internal strains.

In addition to the regular mushroom head, the inlet valve that closes the firing chamber, has 2 rings carried on its stem which cover the air and gas ports

when the valve is closed; these air and gas ports lead to the governor valve.

As the valve begins to open, the ring covering the air port opens slightly in advance of the ring covering the gas port, thus allowing a slight charge of air to enter the clearance space in advance of the mixture. In the case of a slow burning producer gas, this prevents igniting the incoming charge, and as this ring covering the air port is closed last, only pure air is left in the valve cage; hence, back firing is impossible.

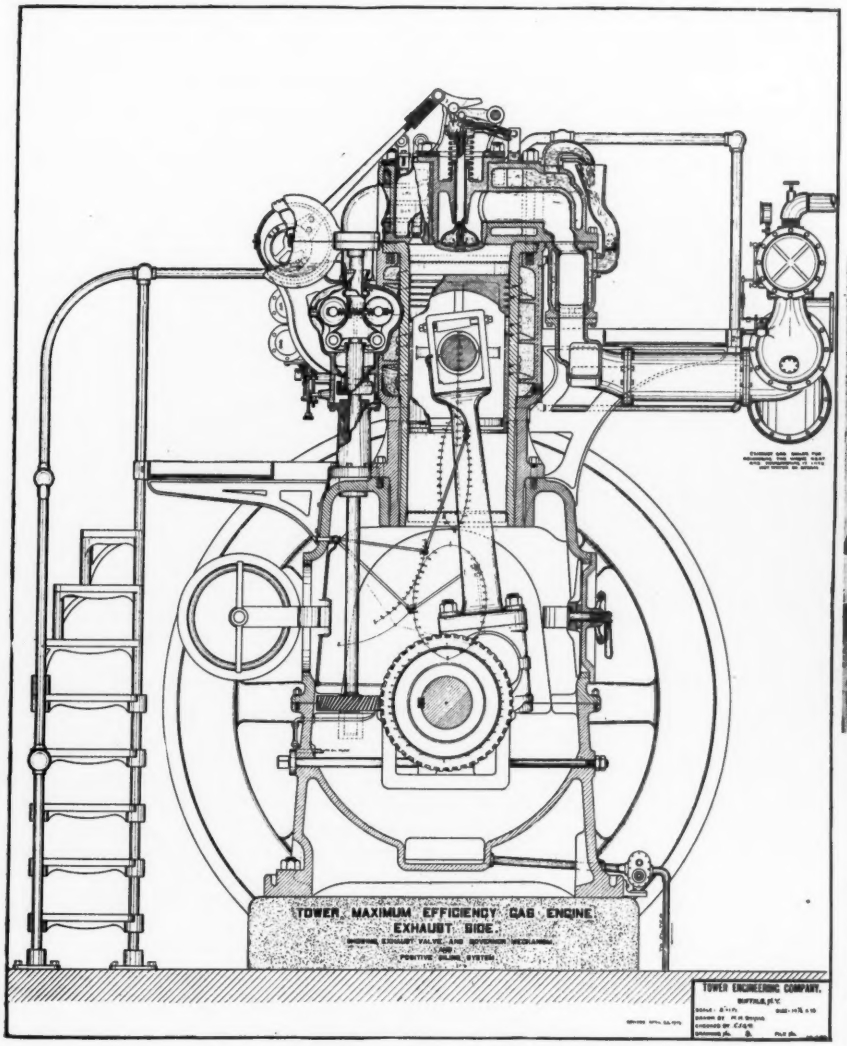


FIG. 3. SECTIONAL VIEW OF TOWER ENGINE

A double opposing series of vanes are arranged in this inlet valve so that a thorough mixing of the air and gas is made just before the supply enters the cylinder.

Exhaust valves are of the water cooled type, the hollow valve head and stem being made in 1 piece. An inner steel tube is threaded into both valve head and retaining nut at the top of the stem, thus preventing the valve head dropping into the cylinder should it for any cause become broken or loose, and this also conducts the cooling water directly onto the valve heads. The water then passes upward through the space between the inner wall of the stem and the connecting steel tube, thus cooling the entire valve head and stem.

Cooling water enters and leaves the valves through adequate and durable flexible connections attached to a retaining nut, always under the observation of the operator.

Each inlet and exhaust valve is driven by a separate eccentric which is adjustably clamped to the lay shaft, placed near the top of the cylinder heads in a convenient position to operate the valves. It is driven by hardened steel spiral gears running in oil and is automatically lubricated. Each eccentric dips into an oil bath in the shaft casing at every revolution of the shaft.

Governing

The governor is of the fly-ball type driven at 1.5 times engine speed and is very sensitive. It has but 2 bearings which are its only wearing parts. These are washers, one of steel and the other of fibre, immersed in oil, which overflows from the eccentric case. The entire governor mechanism is in an oil-tight case the cover of which can be quickly removed for inspection.

FIG. 4. CHANGING THE SPARK PLUGS

The speed of the engine while running is changed by turning a knurled adjusting nut on the outside of the governor stand. Any slight change in the position of the governor balls, lifts the lever that rests on the 2 ring bearings and is connected through a rotating shaft to an adjustable arm on the outside of the governor case. Attached to the ends of this arm are 2 reach rods that extend to and operate the multiple spool valves in the governing valve. The actuating arm is so attached to the rotating shaft that it can be moved up or down in its support by means of a knurled adjusting wheel, thus changing the proportion or quality of the mixture.

The governing valve is constructed to control the quality of the mixture and to regulate the amount of air and gas fed to the engine. As the load on the engine drops, the gas ports are slightly closed and the air ports opened to supply an increased volume of

air, which increases the compression and maintains the efficiency down to very low engine loadings.

This governor valve has large areas, and only a slight movement is required to regulate from no load to full load. An indicator located just below the valve and attached to the operating levers shows the movement of each set of regulating ports.

Ignition

A special low-tension magneto driven by gears from the lay shaft furnishes the necessary electric power to produce a hot spark on the magnetic make and break plugs, and ignite the mixture while the engine is turning over under starting air.

An adjustable timing device which is located on the lay shaft and runs in oil, is so constructed that the timing of each cylinder can be adjusted separately, or the ignition of all the cylinders can be advanced or retarded at the same time by an indicating lever, attached to the gas control of the governor valve. When the load on the engine drops, the gas ports are closed a little and the spark is at the same time advanced.

Each cylinder is equipped with 2 magnetic make and break spark plugs both mounted in a cage that can be turned to place either plug over the firing hole, only one plug being in contact with the burning gases. Either plug can be removed at will for cleaning or inspection, Fig. 5, doing away with stoppages from faulty ignition.

Lubrication

This is by an automatic forced feed system. A sight feed oil pump is located on the engine in sight of the operator, and separate oil feeds are piped down from this pump to each bearing, which has its own indicating sight glass. Each can be so adjusted that more or less oil can be fed to any bearing on the engine. When starting the engine the feeding pumps automatically begin to operate, and stop when the engine shuts down. The waste oil is caught in a reservoir or pit at the bottom of the crank case, to which is connected a filter, which thoroughly cleans the oil. A pump keeps the supply tank connected to the forced feed system filled with oil, no oil being wasted. This entire lubricating system includes the filter and pumps and is furnished with the engine.

Starting Up

On the lay shaft is connected a sliding sleeve on which is mounted an air cam from each cylinder. A distributing valve that connects to a check valve in each cylinder head and which is operated by the cams on the sliding sleeve, distributes the compressed starting air to each cylinder at the right point of the revolution. The cylinder ready to take its working stroke, receives a charge of compressed air just after passing the latest ignition point. If the charge in any cylinder is ignited, the higher pressure inside of the cylinder opposes the opening of the check valve and no compressed air is admitted.

After the engine is under way, a lever connected to the sliding sleeve is moved and the air cams are thrown out of action. A 4-cylinder engine will start from any position it may be in. A 3-cylinder engine sometimes has to be moved or barred over a few degrees only to catch its working stroke and the starting air.

The operator mounts the platform, throws in his distributing air lever, opens the main air valve and the wheels begin to turn at a lively rate. The gas is now turned on and instantly the speed increases and comes up to the operating limit. No change is apparent except the increase in speed, and the purr of the flywheels cutting the air to tell that the engine is now being driven by gas explosions.

The engine runs smoothly and makes little noise because the valves are operated by rolling levers driven by silent eccentrics, and the exhaust gases are used in an economizer that stands behind the engine to reheat the waste water from the cylinders and turn it into hot water and steam for heating and industrial purposes, which action turns to practical use 35 per cent more of the heat value in the fuel, and effectually silences the exhaust.

IGNITION TROUBLES

When an engine refuses to start after plenty of persuasion the trouble is likely to be found with one of the following: dirty valves, carburetor, battery connection.

Of course, when gas is used, there is no carburetor, so that that trouble is eliminated; it is only with gasoline engines that this comes into consideration.

The carburetor is adjusted at the factory to suit the air conditions there, and may not be rightly adjusted for conditions where it is running. Too much gasoline or too little gasoline may give an improper mixture and this is remedied by giving a little more gas or a little more air, as may be required.

If no trouble is found here, careful examination for a broken wire or battery connection will sometimes locate the trouble. This is caused by the constant vibration from the running of the engine and, particularly applies to automobile use.

If there is no trouble with the battery circuit it may be that the cells are run out, and if several cells are in use it may be one cell of the set that is making all the trouble. The only thing to do here is to test the cells with a voltmeter or ammeter to determine their condition.

The spark plug is always a possibility of trouble as it becomes dirty or covered with burned oil and will short-circuit the battery. Points should be absolutely clean and about 1/32 in. apart, and the porcelain surrounding the points should be clean and properly packed and insulated.

Leakage through the bushing is shown by a black streak above the bushing and is remedied by tightening up the bushing or sometimes by putting in new bushing. If none of these examinations reveals the cause of the trouble, there is probably difficulty inside the engine and it will have to come apart.

IN SOME TESTS ON the effect of superheated steam upon valve seats made by the Crane Co., a number of 6-in. flanges of cast iron and cast steel and ferrosteel were made and into them heavy seats of hard metal, nickel bronze and nickel were screwed to a turned shoulder. Keeping these at a temperature of 550 to 700 deg. for 10 hr. a day, 15 days, it was found that after the first day the hard metal and nickel bronze rings were loose and that at the end of the experiment all rings except the nickel could be taken out with the fingers. The nickel rings were all as tight as when first put in.

AN EXCELLENT REMEDY against frost on windows is a mixture consisting of 1 part of glycerine dissolved in 25 parts by weight of 62 per cent alcohol, containing, to improve the odor, some oil of amber. As soon as the mixture clarifies, it is rubbed over the inner surface of the glass. This treatment, it is claimed, not only prevents the formation of frost, but also stops sweating.

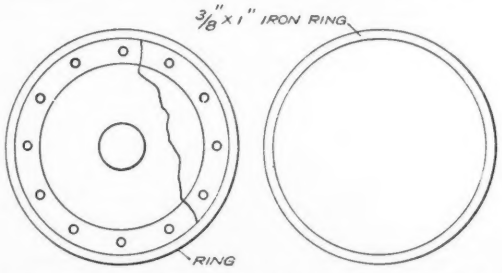
LETTERS FROM ENGINEERS

Send us descriptions of ways of doing new things, and new ways of doing old things. Rough pencil sketches and letters are all right; we will fix them up for the printer. All accepted contributions will be paid for when published.

Temporary Repair Job

Through the sudden closing of all our feed valves on our boiler feed line we cracked our pump cylinder head before the pump stopped. This happened within a few minutes of the noon hour which gave us an hour to repair our pump, if we could do it. We had only the one pump to feed with and no other means unless we brought our pressure down to feed from the city mains, which was about 65 lb. This we intended to do if we did not finish on time. We carried 95 lb. pressure on boilers.

Being near the noon hour, we shut down and had enough water to hold us through until about 1 o'clock or after. The first thing we did was to take the head off and lay it together on the floor. We took the exact diameter of the head and constructed an iron ring



DAMAGED PUMP CYLINDER HEAD AND RING USED IN REPAIRING

of ⅜ by 1-in. dimensions, of a slightly smaller diammeter than the head. We then heated our ring to a red heat, which slightly enlarged it, and forced it on the head. When the ring cooled it was a tight fit, or in other words, shrunk on. All we had to do now was to make a new gasket and put the head on.

It took us just 50 min. to get this done and I believe that it will last as long as the head on the other cylinder.

One good thing about it was that it was an object lesson to our superintendent and we had a relief valve put on our feed line to guard against future possibilities.

You will note in the sketch how the head was cracked and how the ring was slipped over the rim of the head. E. G. S.

Why Does the Engine Pound?

One cause of an engine pound is too much compression. This is borne out by the fact that with an overload an engine runs smoothly, because the effective compression is always only that part of it that is shown by the part of the compression curve that appears above the expansion line of the diagram from the other end of the cylinder. Often in 2 sets of diagrams there is very little effective compression in the diagrams showing a heavy load, while in the diagrams showing a light load nearly all of the compression curve is above the expansion line, and is therefore effective as a retarding force, whereas with the heavy load the forward pressure almost nullifies the retarding effect of compression.

The above seems not to be generally understood, but it is easily demonstrated. I have had cases of this kind in my own experience and the solution of the trouble led to the above. It should be easily seen that the only part of the compression curve that represents effective retarding force is that which lies above the expansion line of the diagram from the opposite end of the cylinder, since the pressures are balanced up to the point of intersection of these lines.

Where release is late on one end, I would advise correcting this, and giving the exhaust valves less lap, so that there will be less compression. I would go far enough with this to prevent this pound even to having a diagram that should show but slight compression, and noting the effect as I proceeded.

Wm. Westerfield.

A New Pump Kink

I am in charge of 2 gas engines, and have my troubles. This is the picture of the cure of one of them.

It is the leather cup packing out of the pump that keeps the cylinders cool. We pump from a pond

THE PISTON WITH LEATHER COVER WHICH DID THE TRICK

through the jackets of a 100-hp. and a 40-hp. gas engine besides an air compressor, and the water runs back to the pond again. The lining wore out and I did not have any to put in, so I had to get busy as we must run.

I took the old lining and cut strips as wide as the wearing edge of the packing and riveted them around the packing, as seen in the picture, which was taken after it had run in the pump for 6 weeks. It shows that it wore perfectly smooth, and the wall of the pump was just as smooth. I was surprised to find it so for the wall was in bad shape when I took the old lining out. This kink saved me a lot of trouble and the firm a lot more. It may help some one else.

W. A. Jones.

An Ice Machine Repaired

Reading Practical Engineer, I find many helpful hints on how to make repairs in the engine room and will give you my experience as machinist in the United States Navy. I was called upon to repair a Dense Air ice machine and after examination, found the water jacket on the air compressor cylinder cracked as shown in Fig. 1, one stud being pulled out, and taking a piece of the casting with it. This caused a leak as shown in Fig. 2. Of course, we wanted that machinery to use at once, and I drilled a ¾-in. hole in the water jacket on the air pump, then cleaned out the

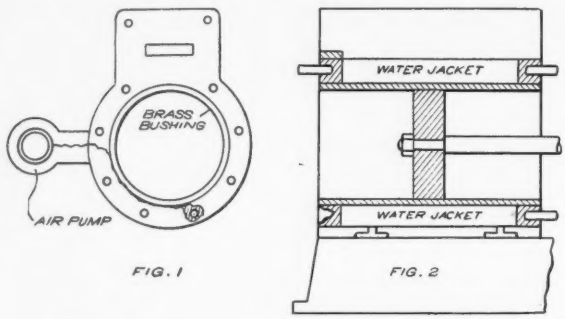


FIG. 1. CYLINDER HEAD SHOWING CRACK
FIG. 2. SECTIONAL VIEW SHOWING WHERE LEAK OCCURRED

crack and filled it with Smooth-On cement and drew it together with a ¾-in. stud, as shown in Fig. 3. I left this over night to harden and in the morning found it very satisfactory, entirely tight and the leak stopped.

To hold the cylinder head tight, under the compression pressure, which was 240 lb., I screwed a ¾-in. stud into the foundation and held the end with a

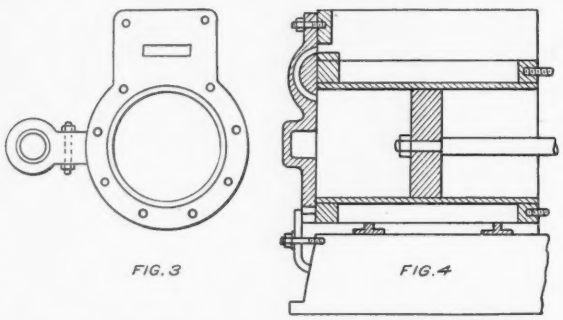


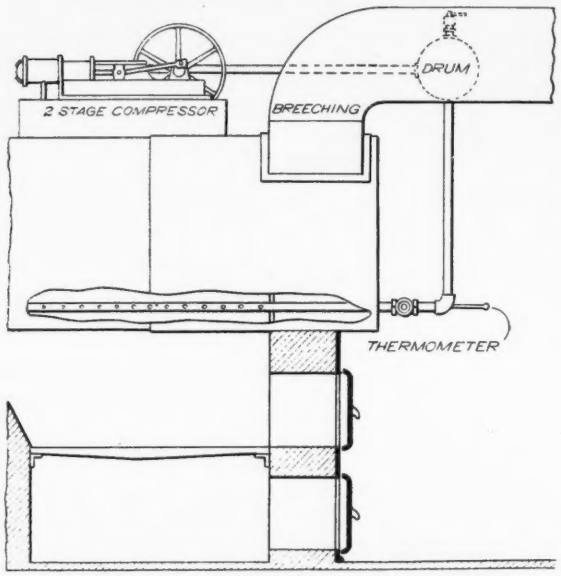
FIG. 3. METHOD OF CLAMPING CRACK TOGETHER
FIG. 4. METHOD OF TIGHTENING CRACK IN BUSHING

clamp, as shown in Fig. 4. The hole in the flange pulled out by the stud was then plugged with Smooth-On cement and after waiting until everything was tight, I started the machine and found no leak. That was about 4 mo. ago and it is still running alright and I would recommend the same method of repair and the use of Smooth-On cement to anyone who has cracks, bad joints, holes, etc., to fix. M. Scrzyczkowski.

Steam and Air Mixture

Having compiled a test of a device similar to the ones described in the Feb. issue for using heated compressed air mixed with steam, for power purposes, it may be of interest to brother engineers to know the results.

The device consists of a Marsh 2-stage high duty air compressor of a capacity of 45 cu. ft. per minute, an 8-ft. by 16-in. steel drum installed in the breeching leading from the boiler to the stack. A pipe runs through the lowest water space of the boiler having ⅛-in. holes drilled at intervals of 3 in. on each side and so arranged as to shoot the hot gases from the



METHOD OF INTRODUCING AIR INTO STEAM

center outward to the sides of the boiler. There were the necessary piping connections, a pop safety valve on the heating tank, a globe valve for regulating the amount of air admitted to the boiler and a thermometer to show the degrees of heat given to the air.

The heat used by this device is what would otherwise be wasted, and as the air enters the water at from 400 to 640 deg. F., we not only get the value of the expansion of the air but raise the temperature of the water.

This device was installed by me in the plant in which I am engineer, as a demonstrating outfit for the

TABLE. PER CENT SAVING DUE TO AIR STEAM DEVICE

APRIL 12	COAL USED		PERCENT OF SAVING	APRIL 13	COAL USED		PERCENT OF SAVING
TIME	WITH DEVICE LB.	WITHOUT DEVICE LB.		TIME	WITH DEVICE LB.	WITHOUT DEVICE LB.	
9:30 TO 10:30 AM	135	175	22.8	9:30 TO 10:30 AM	120	200	40
10:30 TO 11:30 "				10:30 TO 11:30 "			
1 TO 2 P.M	140	210	33.3	1 TO 2	120	190	36.8
2 TO 3 "				2 TO 3			
3 TO 4 "	140	200	30	3 TO 4	160	200	20
4 TO 5 "				4 TO 5			
				AVERAGE PER HOUR	135⅝	195⅝	30.76

Fero American Steam Generating Co., and the table shows the test data for a 2-day run, during which the steam pressure was maintained at 100 lb., air pressure in the tank 130 lb., and the temperature of the air entering the boiler, 420 deg. F. C. D. Ramsey.

Repairing a Steam Turbine

This was a turbine of 500 kw. rating, horizontal type, which had run 17 mo., part of the time as station requirements called for. On opening up a crack was found in the water seal ring, as shown in Fig. 1. This was located as indicated by the arrow, and is shrunk

on a part of the shaft 4.5 in. diameter close up to the larger of the dummy balancing pistons; 0.005 in. is allowed for shrinking on.

When the ring was removed, the shaft was found corroded and the rust had pushed up the ring and

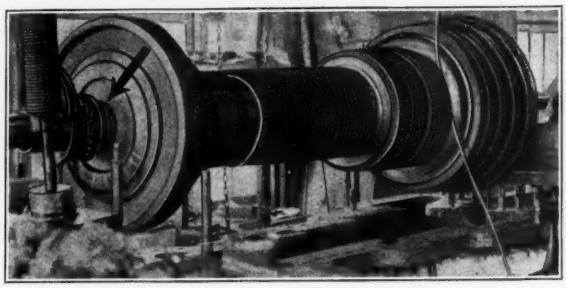


FIG. 1. LOCATION OF RING ASSEMBLED

opened the crack considerably. The shaft was cleaned off, a new ring heated by 3 gasoline hand torches and slipped in place.

This ring is next the dummy and on the other side of the dummy is another similar ring, the group of parts forming a centrifugal pump that makes a water

FIG. 2. CRACK IN RING

seal on the shaft under about 20 lb. absolute pressure to prevent air from entering the low-pressure end of the turbine while running. Frank Martin.

The Best Oil Separator

One of the things that worry engineers most seems to be the getting of cylinder oil into boilers, and its usually bad results, notwithstanding they may possess well recommended oil separators.

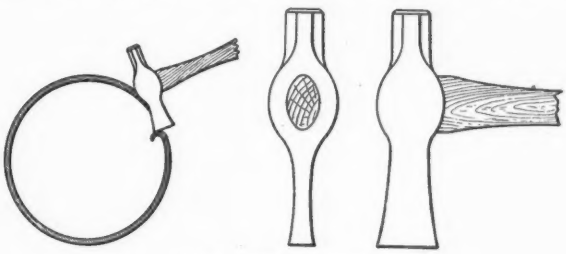
In more than one case I have been fortunate enough to have an extra old boiler of little or no use for steam purposes but making an excellent receiver for the heating system returns by plugging the ends of the tubes with any soft material, thus preventing radiation of heat and cooling the return water. Being large and roomy the water lies quietly, with little or no motion, consequently the oil will rise to the top and float. Once a week all the water is let out and the oil goes with it.

Especially is this of advantage in the vacuum system where, in, extreme cold weather, the cold water jet in the suction of the vacuum pump is used freely, in order to maintain the vacuum, and keep the body of the pump hand warm. During the morning this 5 by 16 ft. receiver will fill up and act as a reservoir and during the afternoon, when the heating is lessened, the cold water jet is open less and the boiler feed pump draws it down to normal. No water is wasted at all, which is far from being the case in the plant with a small receiver, where the returns come in making a great commotion of surging oil and water so near the suction of the boiler feed pump that it cannot help getting oil, hence the oil in the boiler.

Small receivers are responsible for so much oil getting into the boilers. Give the oil a show to do what it is natural for it to do, come to the top away from the suction of the boiler feed pump, and 95 per cent of your trouble will cease. Using the exhaust returns from 2 pumps and a 16 by 48-in. engine and all the cylinder oil they required, my boiler, according to the inspector, was as free from oil as the day it was built. I used no soda ash or anything else except 1 pint of kerosene oil once every 2 weeks and no trace of cylinder oil whatever was obtained. A. Waldron.

Pipe Cutting Kink

In the May issue, on page 311, a pipe cutting tool was shown which Mr. Cederblom calls to our attention, would be almost impossible to work. The draftsman, in an effort to make a tool which seemed to him to have a proper cutting edge, changed over from a



PIPE CUTTING TOOL

square edge to a V edge, with the result of making it a useless device. The shape of the cutting edge should be as shown herewith.

FOR MOVING LARGE GAS ENGINES, J. A. Conley, in *Southern Machinery*, suggests the use of a plank and timber track. He says: "I always used 4 pieces 6 by 8 in. and 8 ft. long, carrying 2 pieces forward while the other 2 are in use. They can be handled much better than longer pieces.

"For rollers we may use 3 pieces of 2-in. shafting 3 ft. long, although pipe and wood can be used where the weight is not too great. First jack or pry up the forward end of the engine high enough to place a roller under the base, then with a bar pinch the engine forward until nearly balanced. Place second roller on the track under the front end and pinch the engine along until it takes the second roller. It will then roll freely, and it is a simple matter to place a third roller in front as the first one rolls out behind.

"Another way to move a large horizontal engine is to build a track so that it just clears the base on each side, so that the flywheels will roll on the track; then after raising the cylinder it can be pushed any distance.

"With a large upright engine lay a track, as described, and then turn the engine down until both flywheels rest on the track. By pushing down on the cylinder end, the base will be raised clear of all obstructions.

AN INNOVATION IN OPEN FEED-WATER HEATERS

In many of the early exhaust steam heating plants, it was attempted to utilize the existing live steam piping, which because of its small size and because of its arrangement, frequently placed a considerable back pressure upon the engine. It was also found that where the engine exhausted directly into the piping system, the latter in time became coated with cylinder oil and greases, so that the efficiency of the radiators gradually became considerably impaired. Because of this oil in the condensed steam and also because of the lack of suitable receiving tanks for collecting the condensed return water, the later was often permitted to run to waste, representing a loss, not only of the water, but also of an amount of heat required to raise an equivalent weight of cold feed water up to the temperature of the return.

Not only this, but the water thrown away, was, except for this content of oil, pure, distilled water containing no scale-forming matter, and unequalled for boiler feeding purposes. The obvious waste in buying or pumping cold water to feed the boilers while hot water was being discharged to the sewer led to the designing of various arrangements and appliances for purifying the exhaust steam of oil and for conserving the returns and reheating them before they were pumped to the boiler.

A great simplification and improvement was gained by the introduction of the open heater, which takes the place, or performs the functions of heater, separator, trap, hot well, cold water regulator and feed water filter and skimming tank, but in order to protect the heating system from oil it is necessary either to pass all of the exhaust steam through the heater or else to install an independent separator with trap in the branch exhaust line to the heating system. The objections to the first method are found in the fact that in order to be able to purify all of the exhaust steam that may be delivered by the engines, an unnecessarily large heater, as regards the water heating capacity, must be installed in order to get a large enough separator to handle the steam, and even then it is not possible to cut the heater out for cleaning while the heating system is in operation.

We illustrate herewith, Fig. 1, a new heater, just introduced by the Harrison Safety Boiler Works, Philadelphia, Pa., by which all these difficulties have been neatly avoided, while certain new advantages have been gained. The new heater possesses all the features of the Cochrane heater, that is, it heats the water by direct, actual contact with the purified steam and pro-

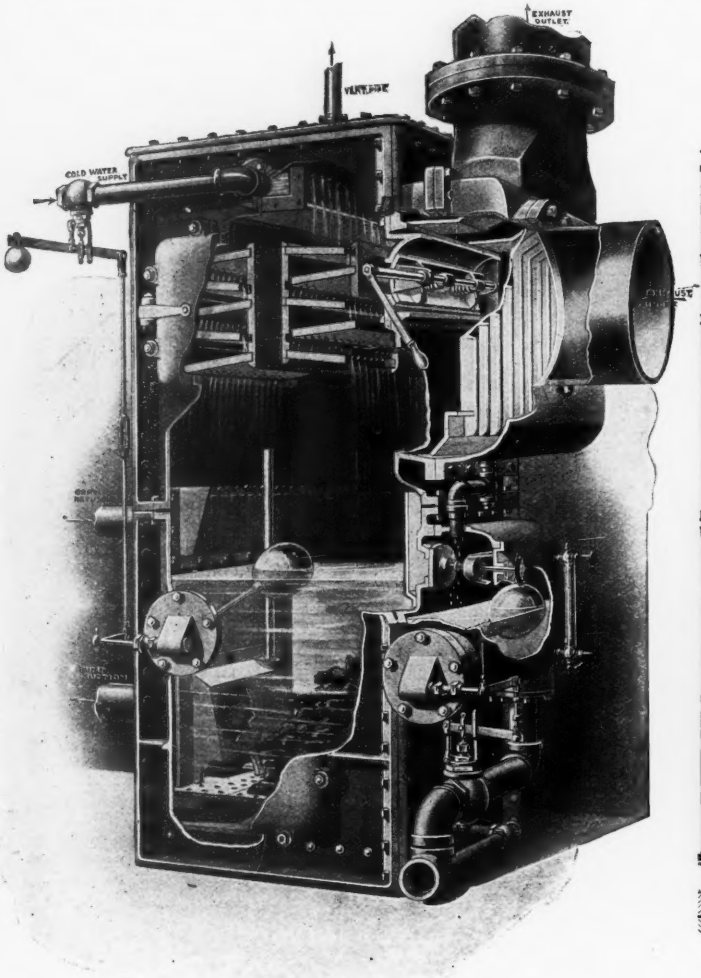


FIG. I. SECTIONAL VIEW OF NEW STYLE COCHRANE HEATER

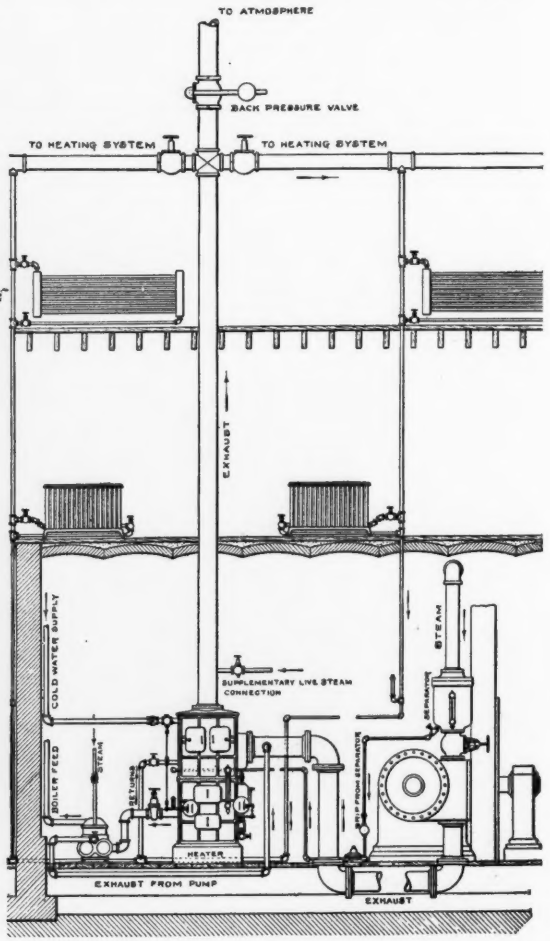


FIG. 3. PIPING VALVES AND FITTINGS FOR OLD STYLE HEATER

vides for the retention of precipitated scale-forming matter on trays and in the filter, for the escape of air and gases and for the automatic admission of sufficient new water to make up the full amount of boiler feed.

The new feature consists of a specially designed separator which is large enough in volume to purify all the steam required for heating the boiler feed water and also to handle the entire amount of steam exhausted by the engines and pumps, so that the surplus can pass directly to the heating or drying system without further purification.

Upon entering the separator the steam strikes a vertically ribbed baffle plate, such as is used in the oil separators attached to other Cochrane heaters, but

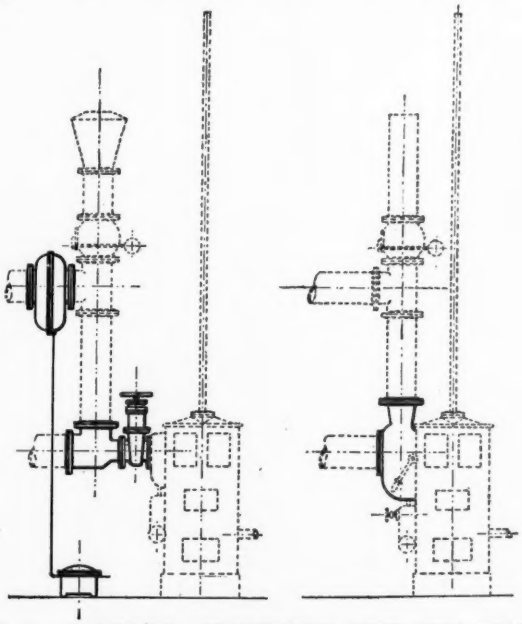


FIG. 3. SIMPLIFIED ARRANGEMENT WITH NEW HEATER AT RIGHT

after passing around the baffle plate, that part of the steam required for heating the feed supply is diverted into the heater proper while the surplus steam is passed to the heating system through the "steam stack" at the top of the separator. The arrangement of parts is such that the preference is into the heater, so that the feed water will be heated up to the maximum temperature before steam passes to the heating system.

Now, to provide for shutting the interior of the heater off from the steam piping, that is, to make it possible to open and clean the heater while the heating system continues in operation, a cutout valve is placed in the opening between the heater and the separator, while a similar valve is placed between the overflow opening of the heater and the steam trap, even when the heater is cut out of service. The steam cutout valve is of cylindrical semirotating type and is operated from the outside by means of a suitable lever.

This large separator with valves thus takes the place, not only of the separator on the ordinary open feed-water heater, but of one or more gate valves and tees, and an independent separator with trap and connections. Comparison of the accompanying illustrations, Figs. 2 and 3, shows the least number of extra valves, fittings, separators, traps, etc., required by an ordinary heater and receiver to perform the functions of the new surplus exhaust and cutout valve heater. In many installations much more complicated arrangements have been installed to perform this service.

For installations where there is no necessity for cutting the heater out of service while exhaust steam is being supplied to the heating system, as where a plant is running during only a part of the 24 hrs., the cutout valves can be omitted, although they are recommended by the builders even in such cases, particularly when the heater is used in connection with a heating or drying system.

LUBRICATION OF ELEVATOR GUIDE RAILS

For lubricating the guide rails of freight and passenger elevators the ordinary method is to slush them "every so often" with cheap grease, which, notwithstanding the low first cost, is unsatisfactory and expensive in the end, on account of the danger of splashing on passengers or goods in the elevator car, and the rapid deterioration of the lubricant on the rails by gumming and the collection of dirt, causing excessive friction. The Keystone Lubricating Co., of Philadelphia, claims that the best and most economical method is to use a refined, high-grade, petroleum-oil grease applied by a simple compression cup lubricating device carried by the car. It is stated that Keystone grease, fed directly to the 3 bearing surfaces of the rail by the imperial lubricator, gives the most efficient combination for this otherwise troublesome detail of the engineer's work. This grease forms and maintains just the right film of lubricant upon the rails, and one filling of the cup of the lubricator lasts for 2 mo. or longer under practical conditions in a large number of the principal office, warehouse and factory buildings of the country.

ELECTRIC TIME SYSTEMS FOR PLANTS.

The reasons for electric systems of distributing time in industrial plants are mainly economic born of modern competitive conditions. The cost of labor and machine work in this country is such that it behooves the manager, who would survive competition to exercise eternal vigilance in economizing time of both men and machines; i. e., making every minute of the working day effective.

The heart of the system is an electric self-winding master clock, which is so made and compensated as to run accurately to within a few seconds per month. It is connected electrically with every other device in the system so as to keep time for the whole. For example, the master clock will control any number of secondary clocks located in various departments, building, or group of buildings, so that each secondary clock will absolutely agree with the master clock and therefore with every other secondary clock in the system. This accuracy and synchronism of time indications is impossible with independent, winding clocks even of very expensive construction.

But the distribution of synchronous time indications is only one function of an electric system. Another useful feature is the program or schedule clock, which is capable of automatically actuating schedules of bells, gongs, or other audible signals in any number of locations desired. One program clock is capable of controlling from 1 to 8 separate and distinct sets of schedules or circuits of signals, and will also change automatically the schedules for different days of the week as may be necessary for any particular business. It may also be used to blow the starting and stopping whistle automatically.

These audible signals in departments, offices, etc., make possible a precision in the use of time in starting, stopping and timing operations and facilitate the harmonious and concerted action of large bodies of men so that a direct improvement in discipline and precision ensues.

Time stamps, time registers, machines, or any other timing equipment may also be controlled through the same master clock.

The operation of an electric system is quite automatic since it is driven by a primary or storage battery requiring renewals only once every 15 or 18 months. The secondary clocks in the system do not have to be wound, regulated, set or oiled, so they may be located permanently at the most convenient points for observation without reference to their accessibility. The mechanism of each clock is only that necessary to drive the hands forward one minute when actuated by an electrical impulse sent out from the master clock on the minutes.

The figure illustrates diagramatically the relations of some of the usual elements in a "Standard" time system as presented by the Industrial Instrument Co. of Foxboro, Mass. This company has gone into the matter of economics of electrical time systems for industrial plants in a quite exhaustive manner, summarizing some of the results and data in a new bulletin, which is now ready for distribution.

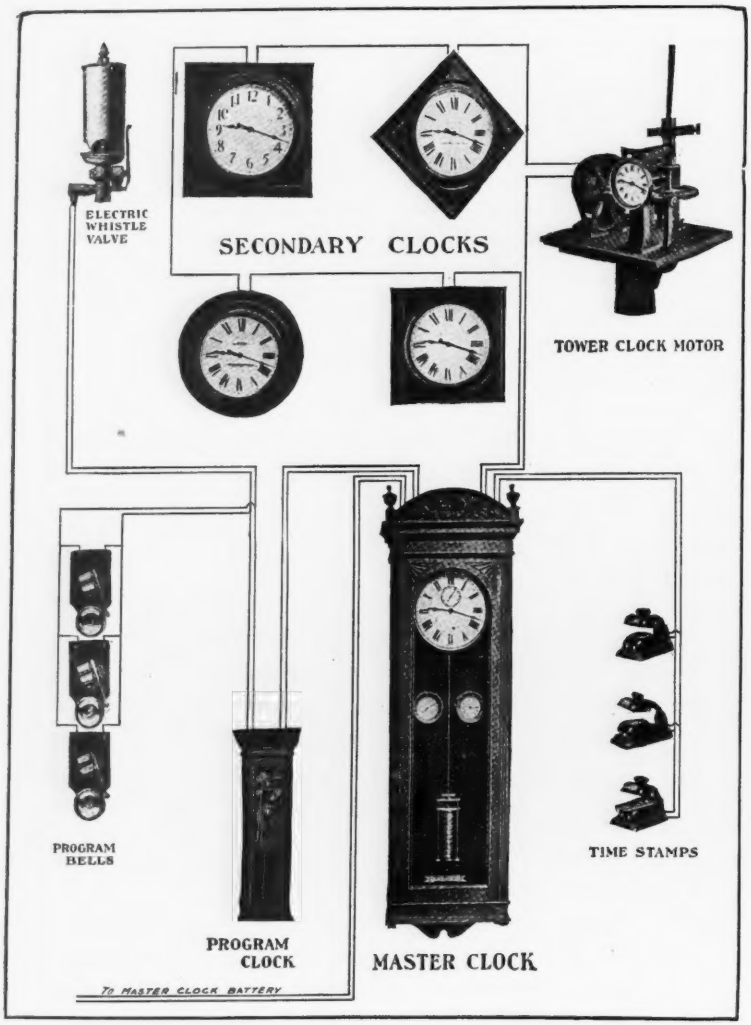
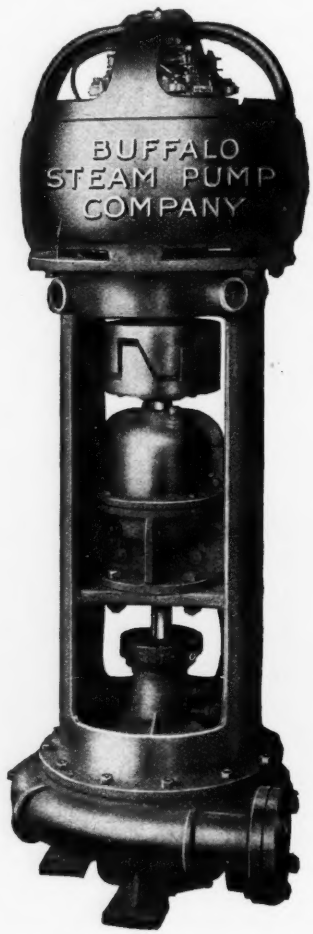


DIAGRAM OF ELECTRIC TIME SYSTEM

MOTOR-DRIVEN CENTRIFUGAL PUMP

The cut herewith shows a pump which is accomplishing rather unusual service, inasmuch as it is used to withdraw the water from the hot well of a surface condenser against a vacuum of 28 in. on the suction side. This vacuum of 28 in. would be equivalent to about a 32-ft. lift, which would not be advisable for a pump of this small size if operating under this suction lift.



VERTICAL CENTRIFUGAL PUMP DRAWING WATER FROM A HOT WELL

That the pump operates successfully is due to the fact that it is placed lower than the hot well of the surface condenser and for this reason water flows by gravity to the pump notwithstanding that there is a vacuum on the suction.

The pump is a 3-in. Class A centrifugal type, manufactured by the Buffalo Steam Pump Co. and driven by a 10-hp. vertical shaft, 600-volt Crocker Wheeler motor operating at a speed of 1,260 r. p. m. The pump has a normal capacity of 215 gal. a minute against a total head of 78 ft., which includes a discharge lift against which the pump handles the water.

Upon the lower-flange end of the main frame is

bolted the pump casing, in which runs a brass impeller machined all over. The brass impeller withstands the extra strains imposed by the hot water. At the top of the main frame is mounted the motor which drives the vertical pump shaft through a flexible coupling. About midway of the main frame the removable thrust bearing housing is suspended from a heavy rib cast integral with the main frame.

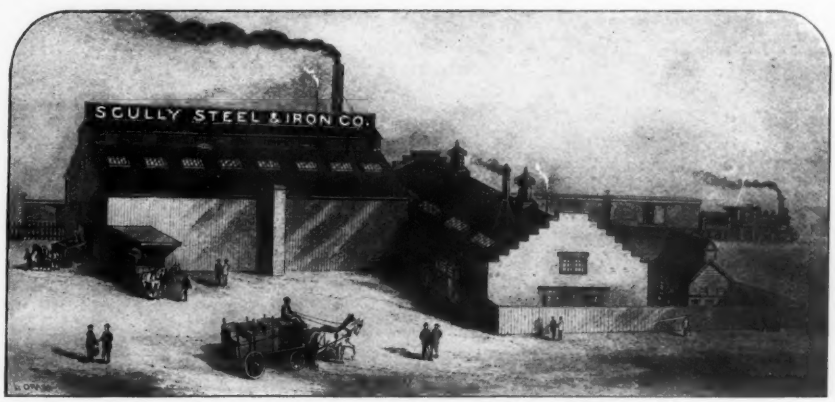
This pump is fitted with a ball-bearing type of thrust and a 5-jaw flexible coupling, but can be furnished with any type of ball, roller or disk thrust bearing and the flange-style coupling with rubber-incased driving pins if desired. It is readily seen that the thrust bearing suspends the weight of impeller shaft and one-half of flexible coupling. The stuffing box on the pump-shaft bearing is sealed against the vacuum which the pump is working against by water pressure through the small pipe shown, the other small pipe providing grease for the bearing.

It is an exceeding simple design, affording access to every part without seriously disturbing the other parts. Owing to the careful design and machining of the runner there is very little loss by slippage and the combined efficiency is very high.

A NEW WAREHOUSE FOR BOILER SPECIALTIES

In Jersey City, N. J., large warehouses have recently been opened by the Scully Steel & Iron Co., whose headquarters are in Chicago, and hereafter a full stock of the boilermakers' and ironworkers' supplies will be carried in the new branch. These supplies will include boiler braces, flanges, pressed steel boiler lugs and crabs, staybolts, patch bolts, taps, tube expanders of all kinds, flue cutters and cleaners, hose couplings, small tools and supplies, and "Everlasting" blowoff valves.

Continued demand from eastern boiler and structural shops for an eastern stock of these supplies has resulted in this new departure, and with the facilities thus created the Scully Steel & Iron Co. will be able to make immediate shipment from stock at Jersey City on all orders from eastern territory. In the warehouses at Chicago is carried one of the largest stocks of boiler and ironworkers' supplies in the world, and the stock at Jersey City will be continually replenished from the home stock so that it will include the complete line shown in the Scully Blue Book, which book is furnished by the company to all its patrons on request.



WAREHOUSE OF SCULLY STEEL AND IRON CO. AT JERSEY CITY

ILLINOIS STATE CONVENTION OF ENGINEERS

THE livest convention of stationary engineers ever held in the State of Illinois was that in Elgin, May 15 last. It was live because the interest was there all the time. Delegates were there to attend to business,—to do all that they could for the progress of the profession, and they spent the time not in congratulating themselves on what had been done but in getting information on what might be done and planning how to do it. Particularly gratifying was the program of the morning session, which sometimes in such cases, under the guise of opening exercises resolves itself into a harmony meeting for patting each other's back. While there was no lack of harmony at Elgin, it was notable that all the speeches of the morning contained good, sound meat and information; none of them were taken up with glorying over the past accomplishments of any persons or of the organization. The spirit in that session, as all the way through, was one of looking forward to the best possible achievements.

The meeting was called to order by E. S. Purdy, president Elgin Association No. 49, and after prayer by the Rev. W. H. Fuller, Mayor Fehrman was introduced and called on his corporation counsel, E. C. Joslyn, to welcome the convention to Elgin, which was done in a happily worded speech having for its keynote the effect which engineers and engineering have on the safety of the public and the growth of the industries of a community. In this speech Mr. Joslyn presented the key of the city, as is most unusual, to the ladies of the convention, whom he regarded as much safer keepers than the men folk.

President Brooker, in his response, spoke of the reasons for the existence of the state association and thanked the mayor and his representative for their cordial greeting. President Purdy then introduced Supt. R. I. White, of the Elgin schools, with the remark that the boys all said that he was a "bully guy" and looked like Lincoln. Prof. White emphasized the value of the boys and girls as the chief product of the state and the great interest in studying the school rooms in which are contained the future leaders of the state and nation. He emphasized the need of keeping our "common schools," in which the common branches needed by the great majority of the people shall be taught rather than fantastic studies or higher branches which can be of use only to the few, and spoke of the rise in civilization which comes to a na-

tion through the wide adoption of common school education.

John W. Lane, past national president and editor of the National Engineer, responded to this address, defining the work of the schools and of the association as along the same lines, viz., the development of the thirst for knowledge which will spur a man always onward to greater accomplishment. He emphasized in particular the sympathy of the engineering colleges and engineering departments of the state universities for associations such as the N. A. S. E., and of the help which might be secured .by co-operation with these departments.

Following this, appropriately, was an address by Prof. Kenneth G. Smith, of the University of Illinois, emphasizing the importance of the power-using industries in the state and of the work which the engineering department and especially the experiment station of the University is doing. Figures which show the growth of power were that in 1870 there was 2,000,000 horsepower of prime movers in the country, which was 0.06 hp. per head of population, while in 1900 the total horsepower was 11,250,000 or a rate of 0.15 hp. per head of population. In Illinois half the population of the state is engaged in power-using industries, including mining, manufacturing and transportation. The activities of the experiment station in testing of coals for both power and house heating, classification of Illinois coals according to their value and work of similar character were explained and an invitation given to the association to hold its next convention at Urbana with the University.

The meeting was then turned over to President W. W. Brooker of the state association, who adjourned the session until afternoon.

At 1:30 the delegates were called to order and the secretary's report and other routine business was taken up, after which discussion was in order of work for the future. The opinion was unanimous that a committee on license law for the state should be kept at work and that such information as had been collected a year past should be put in shape for this committee's use.

Secretary Raven spoke of the need of such a law and the effect which its passage would have on the membership of the N. A. S. E., while Mr. Lane emphasized the difficulties of getting such a law and outlined some of the methods that should be considered in securing its enactment.

A discussion at length on the means necessary to induce all local associations in the state to join the state association was offered by Messrs. Beil of Moline, Randles of Peoria, Moore, Reitz, Allison, Raven, Starr, Misostow and Lighty of Chicago, Brooker of Joliet, Le Mer of Chicago Heights, Stenson of Elgin, Parker of Elgin, and Hill of Moline. The principal points brought up were that the state association should actually do something for the benefit of the locals. The work for a license law is, of course, along this line, but something else of immediate value is needed, and suggestion was made that monthly lists of questions should be prepared and sent out to locals, that a list of possible lecturers and their subjects should be prepared for the reference of local secretaries and other officers, and that a start should be made towards the collection of comparative cost data in regard to the operation of plants. These suggestions were made largely by Mr. Rice, of No. 1 of Chicago, and were approved by Mr. Lane, and on motion of Secretary Raven were adopted for carrying out during the coming year.

GROUP OF DELEGATES, EXHIBITORS AND VISITORS AT THE ILLINOIS STATE CONVENTION IN ELGIN

Prof. Smith again invited the association to meet at Urbana in 1910 and the question of the place of meeting was referred to the incoming officers.

Election of officers resulted in J. L. Randles, of Peoria, as president; W. L. Parker, of Elgin, vice-president; W. E. Hill, of Moline, re-elected as secretary and treasurer.

Resolutions of thanks were passed to the Supply Men, who had contributed to the expense of the convention, to the local committee, whose work had made the satisfactory arrangements possible, to the ladies, who furnished the refreshments, and to the representatives of the technical press for their courtesies and the work done by the papers represented.

After adjournment the inner man was attended to at Unity Hall, where a chicken pie supper was held and in the evening entertainment consisting of lantern slides, a concert and light refreshments completed a most interesting and satisfactory day and one which gave promise of great results for the association.

The firms which contributed to the fund from which the entertainment was provided are as follows:

McMaster-Carr Co., Thayer & Linn, Seehausen & Wehrs Co., Garlock Packing Co., Standard Oil Co., Crew, Levick & Co., Hills-McCanna Co., Hawkeye Compound Co., John A. Roebling's Sons Co., Crandall Packing Co., Greene, Tweed & Co., Viscosity Oil Co., The Lunkenheimer Co., Jenkins Bros., Dearborn Drug & Chemical Works, Chapman Valve Co., Triumph Engineering & Supply Co., Scully Steel & Iron Works.

Some of these firms were represented at the convention and had exhibits there, and others did not, while some firms were represented at the convention who did not contribute to the entertainment fund. The exhibitors and representatives were as follows:

Thayer & Linn were represented by S. T. Thayer.

Seehausen, Wehrs & Co. had on exhibit the Collin pressure regulating valve and gage cock with shutoff valve, made by the Ohio Brass Co., the Seehausen & Wehrs oil filter, samples of the Dods cross expansion packing, Century sheet packing, the Huxley patent valve seat, Huxley exhaust head and separator, Shultz belting, the Semi-Bronze tubular gasket which is made of a combination of asbestos metallic sheet wound around a lead tube, Stephenson bar belt dressing and Wagener steam pumping machinery. This firm was represented by J. C. Eardley.

John A. Roebling's Sons Co., whose product of wire rope sheaves and transmitting apparatus is familiar to everyone, was represented by J. H. Wilson.

Garlock Packing Co. had as its representative H. F. Rall.

Robert E. Hills, of the Hills-McCanna Co., was on hand and proved to be the unwitting means of securing a considerable donation for the Ladies' Auxiliary Association.

Hawkeye Boiler Compound was represented by W. F. Ebert.

Crandall Packing Co. had as representatives G. W. Anderson and A. J. Page.

F. E. Ransley represented Greene, Tweed & Co., and had on exhibit samples of the Palmetto twist packing, Palmetto braided packing, Manhattan packing for hydraulic work, and the Favorite ratchet wrench.

The Lunkenheimer Co. showed a line of its smaller brass goods in charge of E. P. Gould.

Jenkins Bros. showed samples of its valves and packing and was represented by H. B. McLelland.

The advantages of the Everlasting blowoff valve and of the Scully tube cleaner of the Scully Steel & Iron Co. were emphasized by H. H. Gilbert.

H. W. Johns-Manville Co. was represented by J. H. Campbell, of the Chicago office.

Dearborn Drug & Chemical Co. had as its representatives E. P. Poole, A. S. Cook and W. A. Converse.

E. W. Tetlow represented the Revere Rubber Co., of Boston.

The Triumph Engineering & Supply Co. had a notable new device, the Erwood reversible nonreturn cutout valve, which is automatic, working in either direction by adjustment of a couple of set screws and adjustable also for the pressure against which it will close. The representatives of this company were B. M. Knobel, general manager, and T. S. Ross.

McMaster-Carr Co. was represented by Robert McMaster and G. S. Wright.

The technical press was well represented, there being on hand for the National Engineer J. W. Lane, for Practical Engineer A. L. Rice, for Power O. S. Monnett, for the Southern Engineer Robert E. Larkin.

IOWA ENGINEERS IN STATE CONVENTION

Cedar Rapids, May 20-22.

During this 6th annual convention of the state N. A. S. E. of Iowa, headquarters were at the Montrose Hotel and right nobly were the guests entertained. Guests and delegates began to come early on the morning of the first day and found in the north entrance the exhibits taking form. This first day was given to exhibitors, who were taken to the various large plants which might be interested in their lines. Delegates spent the afternoon at the ball game or at plants which attracted them, among these being the big cereal mills of the Quaker Oats Co., where Quaker Oats, Puffed Rice and other brands are prepared, the chief power mogul being Chas. H. Campbell, a prominent member of Cedar Rapids Association, No. 9.

To Frank W. Laas, chief engineer at the street railway power house should be given great credit for the satisfactory way in which the convention was carried through, as he was chairman of the committee on arrangements.

Thursday evening was occupied with a smoker which the proficiency of Louie Shramek of No. 9 as a caterer to the tastes of his brother engineers made particularly enjoyable.

With fully 150 engineers and exhibitors present the formal convention was called to order on Friday morning by President Abner Davis, of Cedar Rapids, who in a neat opening address introduced Mayor John T. Carmody, an active member of No. 9 of Cedar Rapids. His Honor graciously welcomed the convention, commenting on the fact that it was seldom that an engineer had a chance to welcome his brothers in convention assembled. The reply to this address was by National Secretary F. W. Raven, of Chicago, after which President Davis outlined the work of the convention in the transaction of business and the cultivation of the spirit of brotherly helpfulness.

Routine business occupied the rest of the morning. A notable delegation was a class of students from the Engineering Department of Iowa State College, at Iowa City, in charge of Prof. William Raymond.

Friday afternoon was devoted to a paper on Furnace Design and Its Relation to Fuel Economy, by F. W. Laas, supplemented by discussions on different boiler settings, most of which were illustrated by drawings on the blackboard.

At 3:30 special cars were taken for a trip around the city, visiting the packing plant of T. M. Sinclair Co., Ltd., the starch works of Douglas & Co., and finally Beaver Park for a rest after the day's work.

Of interest at the packing plant was the large ice-making department, which, like the rest of the plant, was in charge of James Campbell, where cakes of ice

18 ft. long by 9 ft. wide and 1 ft. thick were turned out at the rate of 50 tons a day. It was fascinating to watch the porkers being put through the mill at the rate of 400 an hour and see the entire process of future hams, bacon, pork and sausages going from the squealing state to the final inspecting room in 15 min.

At the starch works, the oil burners which have recently been installed attracted the greatest interest. Two Erie City Iron Works boilers of 350 hp. each and 2 Wickes Bros. of 250 hp. each constituted the plant. These were formerly fired with chain-grate stokers, at a coal consumption of 90 tons per 24 hr. The oil burners use 10,000 gal. of crude oil in the same period.

delegates from the Commercial Club of Waterloo carried the day and that city was chosen.

In the afternoon, officers were elected as follows: President, A. C. Wilford, Waterloo; vice-president, E. Bailey, Des Moines; secretary, J. A. Coulson, Sioux City, re-elected; treasurer, G. H. Beebe, Marshalltown, re-elected; conductor, H. T. Yust, Ottumwa; doorkeeper, L. J. Shramek, Cedar Rapids. National Secretary Raven installed the officers, assisted by Brother Williamson, of Chicago, and at the close of the installation Retiring President Davis was presented with a silver past-president's badge. Resolutions of thanks were passed to the exhibitors, the mayor and

DELEGATES AND EXHIBITORS AT CEDAR RAPIDS

Dave McKnight, chief engineer of the plant, is pleased with the arrangement and has reason to be proud of his entire equipment.

At the Montrose Hotel on Friday evening a banquet was held, for which music was furnished by the Montrose Orchestra and E. A. Sherman presided as toastmaster. Special speeches were made by F. W. Raven, of Chicago, and A. C. Wilford, of Waterloo. There were a number of short talks by other prominent men.

Saturday morning W. A. Converse, chemical director of the Dearborn Drug & Chemical Works, of Chicago, read a paper on the subject of Boiler Feed Waters, What They Contain and Why They Cause Trouble, which was followed by a spirited discussion of this subject.

Taking up the place of meeting for next year the work of the vice-president, A. C. Wilford, and of 2 council of Cedar Rapids, the press of the city, and the meeting adjourned to meet at the call of the president in May, 1910.

Booths of the exhibitors were all prettily decorated and many of the firms presented the visitors with souvenirs as reminders of the convention. Exhibits were shown by Jenkins Bros. of their line of valves, by the Fisher Governor Co. of its pump governors, by the Lunkenheimer Co. of its lubricating devices and brass specialties, by the Under-Feed Stoker Co. of America of photographs and blue prints of the Jones stoker, by the Scully Steel & Iron Co., of Chicago, of its Everlasting blowoff valves and Scully tube cleaners, by the Lagonda Mfg. Co., Springfield, Ohio, of its Weinland tube cleaners and other steam specialties, by Adkins, Young & Allen of samples of steam goods, McMaster-Carr Co., steam specialties; H. W. Johns-Manville Co., samples of its pipe coverings,

packing and electrical goods; the Vilter Mfg. Co., catalogs of its machinery; C. B. White & Co., of Cochrane, heaters and separators.

Companies represented at the convention but not having exhibits were the Standard Oil Co., the Viscosity Oil Co., Commercial Lubricating Co., Keystone Lubricating Co., Garlock Packing Co., Anchor Packing Co., Greene, Tweed & Co., Crandall Packing Co., Quaker City Rubber Co., Hawkeye Compound Co., Dearborn Drug & Chemical Co., Triumph Packing Co., Great Western Compound Co., the Advance Packing & Supply Co. The National Engineer was represented by its editor, John W. Lane, Power by O. Monnett, and Practical Engineer by H. E. Garrison.

The convention was voted by all who attended to be one of the best and most helpful that has been held in the state association and the outlook for 1910 is most promising.

CORRECTION NOTE

In the article signed by J. O. Parker, in the May issue, Page 291, the 2nd paragraph under the heading "Pressures" states that "If cooled to a temperature of 65 deg. will effect a gain of 65 per cent." This is a typographical error and the sentence should read: "One authority says that with a condensing pressure of 185 lb., with a corresponding temperature of 95 deg., if cooled to a temperature of 65 deg. will effect a gain of 6.5 per cent."

IRA WATTS.

On April 15th, Ira Watts, who was for many years chief engineer of the Knickerbocker Building, in New York City, and who more recently has been consulting engineer in Spokane Falls, Wash., passed away at the age of 49 yr. He was born in Malden, Mass., and early began his career in engineering with the Bell Telephone Co., afterwards going to the United States Navy. He was always active and prominent in the National Association of Stationary Engineers, particularly in the Life and Accident Department, of which he was Secretary and Treasurer for 12 yr. The combined associations of Manhattan and Bronx have adopted resolutions as follows:

"In every association there are a few men who, by reason of their sterling qualities and unselfish devotion, stand out prominently among its membership, and whose counsel and efforts can least be spared to the common cause. Such a man was our late friend and companion, Ira Watts, the news of whose death in far away Spokane, Washington, comes as a blow to us, his fellow engineers and associates.

"An accomplished engineer, a faithful officer, an untiring worker, an exemplary citizen and an ever-ready helpmate, he was an ornament to his profession, a pillar of strength to the association, and an example worthy of emulation to his fellow men.

"The General Committee of the National Association of Stationary Engineers of Manhattan and Bronx, New York, in regular meeting assembled, desirous of giving public expression to their sense of bereavement at his loss, and of recording their appreciation of his high qualities, do hereby.

"Resolve, that in the death of our beloved brother, Ira Watts, the engineers of America and especially the General Committee of the National Association of Stationary Engineers of Manhattan and Bronx, have lost one of their most useful, esteemed and representative members, one whose place in our counsels and in the hearts of his fellow men it will indeed be hard to fill; and be it also

"Resolved, that we extend to those even more near and dear to him the sympathy of fellow mourners and of sharers in the deep affliction which his untimely calling away has imposed upon ourselves as well as them, and be it further

"Resolved, that these resolutions be spread in full upon the minutes, and that a copy thereof be forwarded to the family of our deceased brother."

FRANCIS X. PUND

Francis X. Pund, vice-president of the D. T. Williams Valve Co., Cincinnati, Ohio, passed away at his home, after a brief illness, Saturday morning, May 8.

This announcement will undoubtedly be a great shock to his many friends, as he had been in apparently good health up until several months ago, when he took suddenly ill and was confined to his bed until his death. There were bright hopes for his recovery 10 days before his death came, but he took a sudden change for the worse and died suddenly. The deceased was in his 58th year, and is survived by his wife and 3 children.

FRANCIS X. PUND

Mr. Pund was born in Cincinnati, and at an early age secured a position with Post & Co., and remained with them until the discontinuance of the business. He accepted a position with Post & Co, and after faithfully serving this firm for 8 yr. he and one of his fellow employes, Geo. Puchta, bought out Post & Co., and continued the business under the name of Puchta, Pund & Co., and later as The Queen City Supply Co., which became one of the best-known and successful mill and factory supply houses in the country.

In 1904, after a long and successful career, he entered the manufacturing business, and with David T. Williams, formerly general manager of The Lunkenheimer Co., founded the well-known firm of The D. T. Williams Valve Co., where he eclipsed his former successes, and with his associates helped to build one of the largest valve concerns in the country.

Mr. Pund was a prominent member of various business organizations in which he took a great interest. He is succeeded by Charles K. Thomas, formerly sales agent of the company.

NEWS. NOTES

MEETINGS IN THE DIFFERENT STATES are now in order for the State Associations of the National Association of Stationary Engineers. Dates of conventions are as follows:

June 4 and 5, the Kentucky Association at Hender-

son and the Pennsylvania Association at Erie. On the 5th, the New Jersey Association at Hoboken. The 11th and 12th, the New York Association at Syracuse. The 14th to 19th, the California Association at San Francisco. On the 25th and 26th, the Connecticut Association at Waterbury. In July on the 9th and 10th, the Massachusetts Association at Springfield, and on the 15th, 16th and 17th, the Michigan Association at Bay City.

THE AMERICAN ORDER OF STEAM ENGINEERS will hold its national convention at Reading, Pa., during the week commencing June 7th. Headquarters will be at the Penn Hotel, and a large exhibit of the prominent manufacturers of steam apparatus and supplies is already assured.

ON AUGUST 3RD, 4TH, 5TH AND 6TH, the Universal Craftsmen Council of Engineers will hold its annual Nation Convention at Washington, D. C., with headquarters at the National Hotel.

ON JUNE 22-24 THE NATIONAL Gas & Gasoline Engine Trades Association will meet at South Bend, Ind., with headquarters at the Oliver Hotel. The program is not yet fully completed, but will include papers on the Suction Gas Producer for Small Power Plants, Storage Batteries for Ignition, Running Test of a Gas Engine, Use and Abuse of Water in Relation to Gas Engines, Compression Couplings, Selling Gas Engines through Jobbers and Dealers.

There will be opportunity at the Oliver for the display by manufacturers of small accessory articles which can be placed on tables in the meeting room. Various opportunities for entertainment will be afforded.

The Association is organized to advance the interests of the gas and gasoline engine trade and anyone interested is eligible for membership, which may be secured at the present time by paying $5, the current year's dues.

CARL S. DOW, formerly with the Advertising Department of the B. F. Sturtevant Co. as publicity manager, and previous to that time in charge of the Instruction and Text-book Department, American School of Correspondence, a graduate of Harvard University, has associated himself with the staff of Walter B. Snow, who is engaged in service to advertisers in the line of technical publicity.

MONTHLY MEETINGS of the chief engineers of power stations of the Boston Elevated Railway Co. are now held for the discussion of topics tending to the reduction of operating costs and improvement of service. Comparison is made of the performance of the different plants which comprise 8 steam and 2 gas power with a capacity of 50,000 kw.

JAMES L. ROBERTSON & SONS, INC., and the Eureka Packing Co. Sales Department have removed from 48 Warren St., New York, to a new location in the stores at 78-80 Murray St., New York.

HOMESTEAD VALVE MFG. CO. has secured as representative in Louisiana territory Woodward, Wight & Co., of New Orleans, La. This company will carry in stock Homestead valves and will handle all inquiries and orders from dealers or consumers in that region.

RECENT DEVELOPMENTS in the Engineers' Examining Board of Chicago are not creditable to the administration of this board. State's Attorney Wayman brought before the Grand Jury charges against L. J. Griffin, Secretary of the board, and John Jenkins, a member of the board, for obtaining money under false pretenses. It was charged that Louis Bour of the south side acted as go-between for Joseph Hornyanski, getting him to pay $92, part of which was to be given to the board members, and that Hornyanski obtained his license. Charges that written questions have been furnished to engineers and that applicants have come to the examination with the answers all written out have been made, but none of these seem to have been proved. The President of the board, Frank K. Rittenhouse, is totally blind, and although no charges have been made against him, he has voluntarily resigned as president. He states that there is no power given him to call other members of the board to account and they can do exactly as they please. After the indictment, the resignation of the two officials charged with criminal practice was forced by Mayor Busse and reorganization on totally different lines is now in progress.

THE CHICAGO OFFICE OF THE Atlas Engine Works has been moved from 900 Fisher Building to 1645 Old Colony Building.

THE NINTH SESSION OF THE Summer School for Artisans of the University of Wisconsin begins June 28th, continuing for six weeks. Courses are offered in Steam and Gas Engines, Electricity, Machine Design, Mechanical Drawing and allied subjects.

There are no entrance requirements, the purpose of this school being to offer practical instruction by lectures and laboratory practice to young men in the trades.

Certain advanced engineering courses are offered for those having the requisite preparation, and the general University Summer Session held during the same period allows opportunity for a wide choice in subjects of instruction.

A new feature of the coming session will be courses in Public Utilities testing and accounting, for those desiring to become familiar with the requirements of the Railroad Commission of Wisconsin which has the administration of the Wisconsin Public Utilities Law. Information may be obtained from F. E. Turneaure, Dean, College of Engineering, University of Wisconsin, Madison, Wis.

WAUKEGAN, ILL., ASSOCIATION of Engineers No. 3, at its meeting Saturday evening, May 22, had the pleasure of listening to L. M. Eckstrand, mechanical engineer of the American Steel & Wire Co., on the subject of Coal, J. W. Swearingen, master mechanic of the same company, on the subject of Pumps, and J. W. Townsend on Some Mishaps of the Past.

ON ACCOUNT OF THE INCREASED DEMAND for its product in the Eastern countries the Bird-Archer Co. has opened new offices for the sale of its boiler compound as follows: Honolulu, J. P. Lynch, 42 Young Building; Manila, Lambert Springer Co., 99 Plaza Santa Cruz; Yokohama, T. M. Laflin, Exchange Market; Hongkong, Shanghai, Singapore, United Asbestos Oriental Agency, Ltd. All of these agents have competent steam engineers to direct boiler owners in the proper use of the compounds.

TATNALL ENGINEERING CO., of Philadelphia, has severed its connection with the Wetzel Mechanical Stoker Co. and will no longer handle the product of that firm.

INCREASING DEMAND FOR THE Blackburn-Smith Feed-Water Filter and Grease Extractor has made it necessary for the manufacturers, James Beggs & Co., of New York, to appoint sales agents in all the principal cities. This filter may now be obtained through the following agents, all of whom have competent engineers to explain its operation and the advantages obtained by its use: Boston, Mass., Walter G. Ruggles Co.; Watertown, Conn., M. J. Daly & Sons; Buffalo, N. Y., Buffalo Mill Supply Co.; Pittsburgh, Pa., National Valve & Mfg. Co.; Cincinnati, O., Murdock Mfg. & Supply Co.; De-

troit, Mich., A. Harvey's Sons Mfg. Co.; St. Paul, Minn., R. B. Whitacre & Co.; San Francisco, Cal., Plant Rubber & Supply Co.

Canada. Montreal, H. W. Petrie of Montreal, Ltd.; Toronto, H. W. Petrie, Ltd.; Vancouver, B. C., H. W. Petrie, Ltd.

Porto Rico. San Juan, Lebedjeff & Co. South America: Georgetown, British Guiana, W. G. Harry & Co.

The Blackburn-Smith Filter first became popular for removing oil from the condensed exhaust steam where this condensation must be fed back to the boilers. The filter has been found effective, and is now widely used for the removal of oil from hot well water, open heater returns, etc. It is also efficient in removing mud, slime, and organic impurities in suspension in the water supply.

CATALOG NOTES

TWO ATTRACTIVE BOOKLETS have come to hand from the B. F. Sturtevant Co. of Hyde Park, Mass. No. 105 tells of the saving made by using a "gas booster" to maintain pressure of gas on long lines in a city supply system. No. 106 shows how real ventilation may be obtained in small rooms and houses by using the "Ready-to-Run" electric ventilating set which has a motor driving direct a multivane fan discharging through a canvas hose. The motor runs from a light socket by plug and cord. The fan has an open inlet and discharges through a window or door. It is made in 3 sizes, the largest being 12 in. high and so light that a boy can carry it about.

DODGE MFG. CO., Mishawaka, Ind., in an attractive little folder recently sent out, gives some good advice as to the Selection of Power Transmission Equipment and a list of its publications which help in this problem.

BULLETINS FROM THE WESTINGHOUSE ELECTRIC & MFG. CO. describe 2 seasonable devices. One of these is luminous radiators and air heaters, useful for the cool days of spring and made in 500, 750 and 1,000-watt sizes, also the air heater, which does not have the luminous tubes, is made in sizes from 250 to 700 watts minimum consumption, and 1,000 to 3,000 watts maximum consumption. A second folder describes Westinghouse protective apparatus as applied to overhead lines for protecting machinery and users' apparatus. This shows choke coils, lightning arresters, spark gaps, and other devices used in this work.

THE 18TH ANNUAL REPORT of the directors of the Philadelphia Bourse gives an account of the finances and administration and announces office space still available in the building and floor space in the machinery exhibit.

DEAN BROS. STEAM PUMP WORKS of Indianapolis, in Catalog No. 77, gives a list of parts, direct and geared pumps, and considerable information, all of which will be found of the greatest value to engineers. The book has 76 pages, and every page is good.

INSIDE FACTS ABOUT the hot blast heater coils is the title given to a unique booklet, issued by the Green Fuel Economizer Co., Matteawan, N. Y. As might be expected, it describes the inside construction of the Green heating coils, showing the cross section of header and an improved type of joint.

THE A. S. CAMERON STEAM PUMP WORKS of New York has just issued a new catalog in which the Cameron Condensing Apparatus is described. It shows the arrangement of the jet form of condenser, the barometric jet condenser, and the surface condenser mounted with combined air and circulating pumps.

SMOOTH-ON MFG. CO., of Jersey City, N. J., has recently printed the third edition of the Smooth-On Instruction Book, No. 7, which proves the value that engineers have found in this little book. The company will be pleased to send a copy to any engineer or interested person sending his name and address.

FROM THE HARRIS SMOKELESS FURNACE CO., of Nashville, Tenn., comes a new catalog describing the Harris Smokeless Furnace which combines the functions of a boiler furnace and a gas producer. The object of the invention is to provide a furnace which is arranged to produce a high and complete combustion by burning a mixture of air and producer or water gas, this gas being obtained by superheating the steam, and passing the separated oyxgen and hydrogen in fine jets into the zone of combustion arising from the burning fuel in the fire-box. The catalog shows the arrangement of furnace for horizontal tubular and for water-tube boilers and describes and illustrates fully the details of the furnace. It shows also a number of plants which have used the furnace successfully, both for the reduction of the coal bill and for the prevention of smoke.

IN BULLETIN NO. 4,656, recently issued by the General Electric Co., is described a current transformer for use in connection with the measurement of large amounts of current. These transformers are made in 2 forms; 1 containing both primary and secondary coils; the other containing only the secondary coil, the primary being composed of 1 or more turns of the cable carrying the current to be measured. The former transformer is designed to give 3 ratios of transformation; the latter, 1. Each has a capacity of 40 watts, and may be used on circuits the potential of which does not exceed 2,500 volts. The transformers are portable, and are provided with carrying handles.

THE LATEST IMPROVED ROCHESTER AUTOMATIC LUBRICATORS have many new points of interest to those who are operating machinery and all these points are fully described and illustrated in a new catalog issued by Greene, Tweed & Co., of New York City. The catalog not only shows the different styles of lubricators made and how they operate, but illustrates the method of attachment to different kinds of machinery.

THE GOULDS MFG. CO. Calendar for May is devoted to its force pumps for lifting and forcing water from wells and is accompanied by an interesting circular describing a number of types of pumps for this purpose.

FROM THE AMERICAN BLOWER CO. comes an attractive catalog on the Sirocco fan, invented by S. C. Davidson, of Belfast, Ireland, and heretofore manufactured by the Sirocco Engineering Co. in this country.

WATER SOFTENING FOR LAUNDRIES and the action of a water softener system which is also applicable for the feed water for a power plant is described in a booklet received from the National Water Softener Co. of Muncie, Ind.

FROM THE NATIONAL MACHINERY & WRECKING CO. of Cleveland, O., comes a varied list of second-hand electrical and steam machinery, which includes a. c. units from 60 to 1,500-kw. capacity, belted alternators, railway generators, lighting units, engines, lamps and special machinery.

TRADE NOTES

IN THE POWER AND ELECTRICAL FIELD, figures obtained for March and April from Allis-Chalmers Co., show a large number of contracts for plants of moderate size, averaging about 400 hp., the aggregate of apparatus for which represents the enormous capacity of 161,985 hp. Particularly noteworthy of present activity is a contract placed by The Milwaukee Electric Railway & Light Co., John I. Beggs, president, for 2 1,500-kw. motor-generator sets. 1 500-kw. balancer, 6 2,000-kw. transformers, 2 300-kw. transformers, 2 300-kw. motor-generator sets, and a 300-kw. generator of the water-wheel type, much of this apparatus constituting a repeat order.

THE NATIONAL FLUE CLEANER CO., of Trenton, N. J., which manufactures the American Boiler Flue Cleaner, reports the following sales recently: J. & P. Blatz Brewing Co., C. Schmidt Sons Brewing Co., Schofield & Newton, Ritter Bros. Chair Factory, Wm. Ayres & Son, John H. Earley, Phillips Pressed Steel Pulley Co., McAndrews-Forbes, Kensington Hygia Ice Co., all of Philadelphia; A. H. March, Bridgeport, Pa.; Metropolitan Electric Co., Reading, Pa.; Trenton Street Railway Co.; and the following other firms from Trenton, N. J.; John Maddock & Son, Trenton Worsted Mills, Windsor Hotel Co., Keystone Pottery Co., The Star Porcelain Co., New Jersey State Home for Girls, Joseph Stokes Rubber Co., Acme Rubber Mfg. Co., and also the Union Mills Paper Mfg. Co., of New Hope, Pa.

IT IS STATED BY THE Keystone Lubricating Co., Philadelphia, manufacturers of the Keystone grease, that this product is successful for the lubrication of large engines and that it compares favorably with lubricating oil in economy, and in power and labor saving. Among the pumping stations that are employing Keystone grease one of the largest is the Queens County Station at Valley Stream, Long Island. This station contains 2 8-million gal. vertical triple-expansion pumping engines. It is claimed that a saving of between 80 and 85 per cent is made over lubricating oil formerly used, with no increase in the friction load. This figure allows for the oil that was filtered and reclaimed.

GEORGE A. THATCHER & CO. of Albany, N. Y.,, describes in Catalog G the Coe shaking and dumping grate, and in a second one the Coe improved combustion and draft system.

WANTED

"Positions Wanted" advertisements not exceeding 50 words for subscribers to Practical Engineer will be inserted twice free of charge. "Help Wanted" and special advertisements 25 cents a line.

PATENTS

Watson E. Coleman, Patent Attorney, Washington, D. C. Advice and books free. Highest references. Best services. 4tf

POSITION

By engineer, employed at present but desires change for reasons. Experienced in operating Corliss and automatic engines, A. C. machines and Fort Wayne street arc machines. Address Box 104, care of Practical Engineer. 6-2

POSITION

By young man, 24 years old, as oiler or helper. Have had 2 years' experience in power plants. Can furnish best of references. Address Box 103, care of Practical Engineer. 6-2

POSITION

As stationary engineer in small power plant by a young man 27 years old. Has had some experience with dynamos. Owns tools for cutting and threading pipe. Best of references. Address Albert B. Howard, Bidwell, Ohio. 6-2

POSITION

As first class electrician in plant of any capacity. Am experienced with all classes of direct and alternating current machinery, switchboards, wiring and transmission lines, also central and substations, etc. Formerly employed by largest electric light and power and industrial concerns in Pennsylvania. Would like to hear from interested parties. James E. Kilroy, Box 31, Lincoln place, Pennsylvania. 6-2

POSITION

By young man, 23 years old, in drafting room or machine shop. Am a student and a good worker, with good habits. Hold first class engineers license. Am about to graduate from A. S. C. in mechanical engineering course. Address John L. Kuhn, 7th street, N., Fargo, N. D. 6-2

POSITION

Engineer, 40, machinist by trade, college graduate, long experience, highly recommended, wants position as chief engineer in hotel, office building or factory. City or country. Results guaranteed. Address Box 102, care of Practical Engineer. 6-2

POSITION.

By first class marine, stationary and electrical engineer; twenty years' experience as engineer and electrician. Good machinist, steam fitter and general power plant mechanic. Understand making all necessary repairs. Not afraid of work. Sober, man of family. South preferred. State salary. Address Box 100, care Practical Engineer. 5-2

POSITION.

By young man, age 39, married, electrician, T. B. E. W. Has fair knowledge of taking care of low pressure boilers and engines and electric plants. Steady and can offer good references. Eight years' experience. Address Charles C. Gladwin, 249 East 45th street, New York City. 5-2

POSITION.

As superintendent in plant under 1,000 H. P., or engineer in plant over 1,000 H. P. Six years' experience with A. C. and D. C. dynamos, high speed and Corliss engines. Strictly sober and steady; moderate salary to start; references. Address Electrical Engineer, Box 79, South Dayton, N. Y. 5-2

POSITION.

Railroad clerk and telegraph operator, 21 years old, college education, wishes position pertaining to shipping and receiving freight with some firm. Could also assist in drafting room. Address Box 112, New Castle, Dela. 5-2

POSITION.

By technical graduate, 32 years old. Five years' experience with A. C. and D. C. machines and equipments, all details of substation construction and operation. Have also had experience with steam. Desire position as assist superintendent or foreman of power plant, hydraulic or steam. Prefer South or West. Address Box 101, care Practical Engineer. 5-2

POSITION.

By young man in machine shop, with mechanical engineer, or in drafting room. Graduate of International Correspondence School in mechanical drawing. Age 27, good habits, not afraid of work. Address H. J. Postlewait, Box 23, Dayton, Pa. 5-2

POSITION.

By young man, 20 years old, as oiler and wiper in an engine and dynamo room. Have completed I. C. S. course in dynamo running. Some experience in steam engineering. Strictly sober, good references. Address J. Evert Snell, Bunker Hill, Miami Co., Indiana. 5-2

FOR SALE

60 steel storage tanks, 6,000 gallons' capacity. Good as new. Double riveted, extra well built. Suitable for storage of oils, waters or liquids of any kind. 100 steam pumps. Get our prices on engines, boilers and electrical machinery. All sizes and kinds. Chicago House Wrecking Co., 35th and Iron Sts., Chicago. 4 tf

ENGINEERS AND MECHANICS

To make big money selling Incomparable "ZIZ" Hand Soap. A 10-cent can will instantly remove more dirt and stains from the hands than four cakes of any soap made, and it will not injure the most delicate skin. Small sample free. Byram Mfg. Co., Box 3133, Boston, Mass. 4 tf

POSITION

Asiatic agency wanted for American machinery by Japanese technical graduate, age 35, five years experience in leading railroad company as draftsman, also electrician and machinist. Address T. I., 312 South Carolina avenue, S. E., Washington, D. C. 6-2

PATENTS

C. L. Parker, late Examiner, U. S. Patent office, Attorney-at-Law and Solicitor of Patents. Patents secured promptly and with special regard to the legal protection of the invention. Handbook for inventors sent upon request. 186 McGill Building, Washington, D. C. 4 tf